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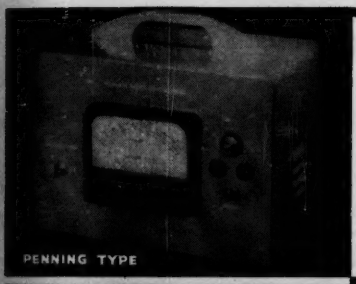

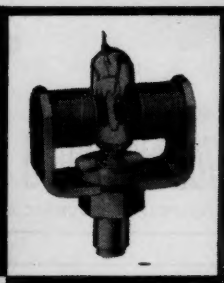

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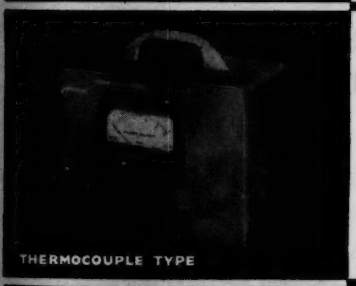

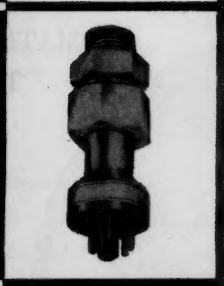

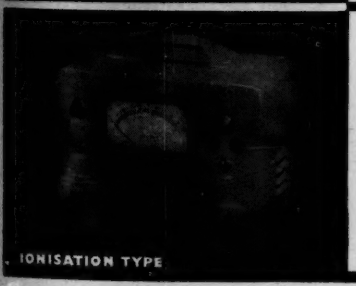

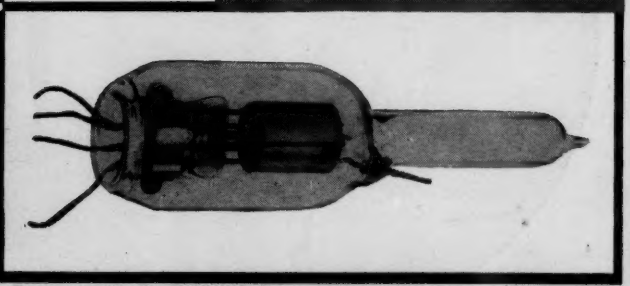

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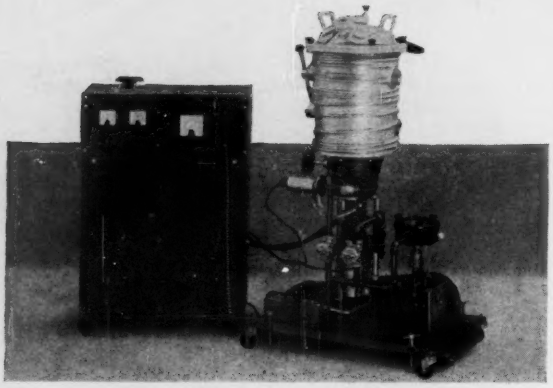

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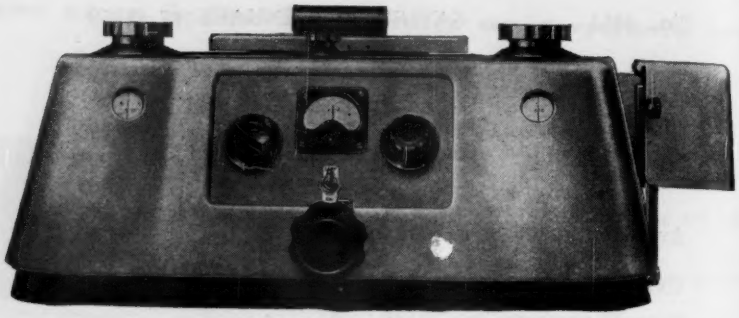

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AVAILABILITY OF SCIENTIFIC INFORMATION

IN January 1958, important statements regarding scientific publications in the United States, abstracting and the retrieving of scientific information were made to a Sub-Committee of the Congress Committee on Government Operations by such leading scientists as Dr. L. V. Berkner, president of the International Council of Scientific Unions, Dr. W. R. Brode, science adviser to the Secretary of State and president of the American Association for the Advancement of Science, Dr. D. J. Hughes, of the Brookhaven National Laboratory, Dr. H. T. Cox, director of the American Institute of Biologica Sciences, and Dr. Warren Weaver, of the Rockefeller Foundation and the National Science Foundation. Dr. Berkner suggested that absence of knowledge of work done elsewhere was probably the greatest cause of inefficiency in research, but he stressed the value of personal contact between scientists. He went on to recommend that the National Science Foundation should give immediate support to scientific periodicals and specialized publications, to permit and encourage prompt and full-scale publication in English of scientific literature and provide for its abstracting. He also recommended provision for encouraging and financing publication of U.S. Government research papers in recognized scientific periodicals and discouraging unnecessary use of Government research reports. International activities in the publication of scientific symposia and international efforts to improve the publication of abstract periodicals should also be supported, and the translation of scientific papers into English, the unification of translation by different agencies and prompt publication in periodicals regularly acquired by libraries should be subsidized.

With the immediate initiation of substantial and continuing research on subject classification, indexing and procedures for retrieving, designed to provide the scientists of the United States and other Western countries with full access to the scientific literature of the world, Dr. Berkner thought such a programme would repay its cost many-fold. He reiterated his belief that national security is based ultimately on an adequate supply of sound and effective weapons (and men well trained in their tactical use) from a virile industry; on the recognition and public debate of weaknesses so that they can be corrected; on a free and unfettered science and technology; on a free and imaginative industry with full access to all knowledge; on allies and friends, with whom scientists can deal freely and with a sense of full trust; and on a society built on the foundations of mutual confidence upon which free enterprise depends. Dr. Berkner, it will be noted, recognizes the need for further sustained research into methods of retrieving information in the widest sense, and in this he was strongly supported by Dr. Hughes, who made this one of his main recommendations.

Dr. Cox, who, like Dr. Hughes, also urged the need to increase the American national effort in fundamental research, suggested it might well be doubled, to a figure of 800 million dollars (including private funds); he referred also to the need for investigating new methods for the rapid publication of scientific papers, as well as for the more efficient and cheaper printing of scientific periodicals, but he was concerned as to the danger of excessive centralization and did not view with favour gigantic national centres. In this he was supported by Dr. Weaver, and there was general agreement in these statements that the policy and control of such scientific projects must be in the hands of scientists themselves. Dr. Brode, who stressed particularly the magnitude of the present problem of retrieving information, strongly supported Dr. Berkner's proposal that funds should be available to the National Science Foundation to support studies in this field, but he was hopeful that the President's Advisory Committee on Science might help to solve some of the problems.

Dr. Weaver urged particularly the importance of a careful approach and considered order of priorities, suggesting that the problem would be clarified by the International Conference on Scientific Information which was to meet at Washington in November. We need, he said, to clarify the actual and proper purposes of publication, if only because the recorded word, at best, is a cold substitute for direct communication between scientists, and he stressed the value of removing hindrances to travel. Moreover, it was not simply a matter of communication between scientists themselves, but also of communication between scientists and the public. Dr. Weaver concluded by outlining a programme of public relations with three specific points, which embraced provision through the National Science Foundation of special fellowships for training young men and women in writing, in journalism and in the techniques of mass communication in science so that they could act as a communication link between science and the public; the provision of funds to assist the American Association for the Advancement of Science to pursue its own plans in this field; and requiring the major Government agencies concerned with fundamental research to provide intelligible and candid reports of their activities to the public. He reiterated the importance of giving Dr. J. R. Killian, special assistant for science and technology to President Eisenhower, full support, and of using the National Science Foundation and existing agencies to the full. In particular, he thought the Division of Information of the National Science Foundation, with adequate staff and support, would be ideally placed to deal with the information problem.

The Congress Committee was primarily concerned with the availability of information from Federal Departments and Agencies, although, as has been

seen, no narrow view was taken of the information problem, and the use of the departmental research report was firmly discouraged by those who gave evidence before the Committee. The scope of the International Conference on Scientific Information at Washington (see p. 147 of this issue) was similar for, although its discussions were nominally concerned with problems of storing and retrieving information, panels examined the literature and reference needs of scientists, the effectiveness of abstracting and indexing services and also of monographs, compendia and specialized centres. Moreover, in his opening address, Sir Lindor Brown was no less searching and forthright than Dr. Weaver in the questions he raised about the purpose of publication, and the need for discipline and critical thought.

Many of the points emphasized before the Congress Committee recurred in the discussions at Washington, notably in those of the panel concerned with the responsibilities of governments, scientific societies, universities and industry for improved information services and research. The panel did not favour the establishment at present of an international scientific information centre, but rather the co-ordination of national services, for example, through national library services. The trend should be for more national centres and more international co-ordination.

The plan, approved on December 7 by President Eisenhower, for improving the availability of scientific and technical information in the United States is entirely in line with the trend of opinion at the Conference and with the views expressed to the Congress Committee last January. It is based on the findings of a report of the President's Science Advisory Committee, of which Dr. J. R. Killian, special assistant to the President for science and technology, is chairman, and Dr. L. V. Berkner is a member. The President's action reinforces the provision of the National Defence Education Act, 1958, which called for the establishment of a Science Information Service in the National Science Foundation to "provide, or arrange for the provision of, indexing, abstracting, translation, and other services leading to a more effective dissemination of scientific information, and undertake programmes to develop new or improved methods, including mechanized systems for making scientific information available". The President has now directed the National Science Foundation to take the lead in co-ordinating scientific information activities within the Federal Government of the United States and has asked all Federal agencies with programmes involving scientific information to co-operate with the National Science Foundation in improving the Government's efforts in this area.

The International Conference alone demonstrated the large extent to which scientific information services present problems common to all nations, even if solutions to particular problems may vary from country to country. This report of the President's Science Advisory Committee is thus of great interest to Britain, and apart from its bearing on the organization of a national library service for science and technology now belatedly under consideration, its clear presentation of the magnitude of the problem and its gravity may well help to convince those in authority that the projects under consideration in Britain should receive more urgent and generous support than the Advisory Council for Scientific Policy has yet been able to command. The consequences of delay can no longer be ignored, and the extent to which responsibility falls on the Government is clearly indicated.

Dr. Killian remarks that there are some 55,000 journals appearing annually, containing about 1,200,000 articles of significance for some branch of research. In these fields, more than 60,000 different books are published annually, and about 100,000 research reports remain outside the normal channels of publication and cataloguing. This vast body of scientific information, much of it in languages, such as Russian and Japanese, unknown to most English-speaking scientists, contains the technical data needed by scientists to do their work. The rate of increase is indicated by the doubling every twenty years during the past century of the collections of science and technology periodicals in the Library of Congress. These now contain a million and a half volumes, and about 15,000 are received annually, with 1,200–1,300 new periodicals appearing each year. By 1979, it is expected that the world output will reach 100,000 periodicals.

At present a mounting flood of scientific data threatens to swamp even the most zealous research investigator; yet our very progress in science depends upon the free flow of scientific information. After reviewing what is already being done in the United States—where the fourteen major scientific abstracting services are estimated to cover, with their half-million abstracts, only about 55 per cent of what is needed for reasonable cover—and stressing a recent trend in the establishment of data centres, the report firmly rejects the proposal to establish a single and highly centralized scientific information agency, financed wholly or partly by the Federal Government, on the lines of the Soviet All-Union Institute of Scientific Information.

The President's Committee does not believe that the needs of the United States, where the research effort is organized and administered on very different lines from that of Soviet Russia, would be met effectively in this way. A long-term solution of the problem requires fundamental research into the problem itself and widespread application of mechanical methods and techniques. The Committee considers that the needs of the United States would be better met by establishing a science information service of the co-ordinating type, which would strengthen and improve the present system by taking full advantage of existing organizations and the special skill of persons with long experience in this field. Such a service, in the best American tradition of private enterprise and Government working together voluntarily for the national good, would have two important functions. First, by effective co-ordination of public agencies and private

organizations, it would improve existing facilities and techniques, so as to afford immediate relief to the most urgent short-term problems. Secondly, it would encourage and support the fundamental long-term programme of research and development, with the view of applying modern scientific knowledge to the whole problem, both by the use of mechanical techniques and the discovery of new methods.

Under the first category, the service would assist financially, where necessary, the publication of periodicals and monographs, encouraging also both publishers and scientific societies to experiment with new methods of publication. It would also sponsor and, if needed, support the immediate preparation of world lists of both primary and secondary scientific research publications, classified by subject and indexed, as well as sponsor a list of scientific and technical periodicals and provide a clearing house of information on abstracting and indexing services throughout the whole area of foreign scientific information, expanding the translation of Russian periodicals and initiating additional translation programmes in Japanese and other languages as required.

The service would give special attention to Government scientific reports, expanding the existing system of announcement to include all significant unclassified reports and improving facilities for making copies of these reports available on request. It would also seek to expand and improve throughout the world inter-library exchange agreements, photocopying processes, and other means of bringing to the scientist copies of items unattainable through normal channels. With sufficient funds and support, all this could be attempted at once; but in addition, under the second category, the service would support a continuing programme of research and development through grants and contracts, looking to the widespread application of mechanical techniques to such problems of storage, retrieving, indexing, translating and abstracting.

As already indicated, the Science Advisory Committee does not consider that a new agency is required. The National Science Foundation has specific responsibilities in this field, and a pilot programme has already supplied useful experience and special competence. The Science Information Service could easily be established within the Foundation by extending the Foundation's present programme, and this is the Committee's recommendation and the purpose of the President's action.

It will be apparent from this summary that what is now contemplated in the United States goes far beyond the present activities and responsibilities of the Department of Scientific and Industrial Research in Great Britain. A comparable activity in Britain is that of the Association of Special Libraries and Information Bureaux, which is now turning its attention to the long-term problems of research and development. Further, the Nuffield Foundation has for some time been seeking to foster the examination of new techniques of publication; and Anglo-American co-operation in translating Russian periodicals has already been instituted. The American report demands the considered attention in Britain both of the Advisory Council for Scientific Policy and of the Roberts Committee, which is inquiring into the public library service of the country. Apart from this, it should assist the Parliamentary and Scientific Committee and all who realize the magnitude and seriousness of the whole problem to impress on the Government the need for urgent and adequate action, and for an end to the procrastination and delay that for more than a decade have led to the waste of much scientific effort and man-power.

UNIVERSITY COLLEGE, IBADAN

The Birth of Nigeria's University

By Dr. Kenneth Mellanby. Pp. 263+9 plates. (London: Methuen and Co., Ltd., 1958.) 25*s*. net.

THIS is an autobiographical and personal book. It records the part which Dr. Kenneth Mellanby played for six years as the first principal of University College, Ibadan, Nigeria. When he arrived in 1947 the site was a piece of unsurveyed bush. When he left in 1953 it was a flourishing college presenting candidates for degrees in the University of London and with buildings which many British universities might envy.

Dr. Mellanby writes with sincerity and candour. He makes no secret of the fact that some of his policies were criticized both in Britain and in Nigeria. It is still much too early to judge whether he or his critics were right. Nor does it matter in this book who was right. What matters is the record of what it is like to build a university in tropical Africa, written while it is still fresh in his mind by a man who has built one.

When a university begins as nothing more than two or three square miles of uncleared tropical bush, the first principal (Dr. Mellanby says) must regard himself as expendable. He has no council, no senate, to approve his actions. Every day he has to decide either to do something by unorthodox methods or to run the risk that it will not be done at all. Once the apparatus of academic government is set up, the principal of an African college finds himself to be the point of attachment of three forces which rarely pull in the same direction. London provides money for capital expenditure, coupled with liberal issues of advice which the principal cannot lightly disregard. The local government and Press shower criticism (often only for political reasons) upon the principal; this, too, he cannot lightly disregard. And his own freshly constituted and inexperienced council and senate observe him suspiciously for symptoms of autocracy, and test their untried authority by questioning his policies and slowing down the pace of his pioneering efforts: this force, too, he disregards at his peril.

Dr. Mellanby describes (subjectively of course, because he is still too close to events) what it is like to be acted upon by these three opposing forces. He raises questions which are fundamental to the whole experiment of exporting the English university system to tropical Africa. Chief among these is the question of academic standards: Should academic standards for African universities be from the outset as high as academic standards for the University of London? On one hand many Nigerians would indignantly reject the suggestion that an Ibadan B.A. should be lower

in standard than a London B.A.: on the other hand, many Nigerians are impatient that, in a country which needs graduates urgently, so few students graduate from Ibadan and such high standards of entry are demanded. This is one example of the massive unsolved problems which accompany the experiment of exporting the University of London to the African bush. Dr. Mellanby's book is a welcome record of the sincerity and enthusiasm of those who took part in founding Nigeria's university, and the sustained help which the University of London has given to the cause of higher education in the Colonies.

E. Ashby

FROM CONDUCTORS TO TRANSISTORS

Electric Conduction in Semiconductors and Meta!s By Dr. W. Ehrenberg. Pp. x+390. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 63*s*. net.

THE scope of work on semiconductors has increased in recent years to such an extent that it is no longer practicable for one book to cover the whole field in detail. Dr. Ehrenberg has therefore wisely confined his attention to transport properties, leaving on one side studies of magnetic susceptibilities and surface adsorption (for example), and giving only little space to questions of absorption and emission of infra-red radiation and of X-rays (5 and 3 pages, respectively). If this restriction is granted, it is convenient to treat the subject under the following broad headings.

First, the theoretical basis of band theory and its experimental checks are discussed. This is fundamental for both equilibrium and transport properties. The author spends Chapters 5 and 6 on this topic (65 pages), half the space being devoted to the wave-mechanical problem. He gives a clear introduction which should enable the reader to pass readily to more advanced discussions. This applies in particular to the author's introduction to Bloch's theorem, which he makes plausible in a very simple manner. It also applies to the concept of Brillouin zones, which are introduced by reference to the simple cubic lattice, rather than by more general arguments.

Secondly, an account is given of electron scattering and times of relaxation. Whereas for band theory one could refer the reader to existing standard texts (though, strangely, this is never done in books on semiconductors), this second topic is characteristic of transport phenomena, since it includes the origin of the electrical resistance of materials. The author treats this subject on pp. 55–63 and in Chapters 7 and 8 (a total of 51 pages). A full account of lattice scattering and of the original treatment of ionized impurity scattering is given here, but neutral impurity scattering receives only a brief mention (p. 244).

Thirdly, armed with this theoretical equipment, the author derives more or less formal expressions for the transport coefficients (conductivity, magneto-resistive ratio, Hall and thermo-electric coefficients, etc.), under various conditions of scattering (Chapters 4 and 9, 35 pages). These may then be compared with experiment (Chapter 10, 54 pages). It is good to see that the author has here not restricted himself to germanium and silicon, but has gone on to discuss the older low-mobility semiconductors, on some of which new work is badly needed. On the other hand, results for metals are scarcely discussed, and topics such as the skin effect in metals are also not treated, so that the term 'metals' in the title could be misleading.

The reader should be warned that some of the results in Chapter 4 appear in unfamiliar guise. The reason for this is that the author gives simple but approximate expressions for the Fermi integrals (p. 38):

$$\int_0^\infty \frac{x^n dx}{1 + \lambda \exp x} \sim \frac{a_n}{\lambda + b_n}$$

where a_n, b_n are numbers, and sometimes uses these in the standard results. The numerical information concerning the a's and b's is new, and, as an error of less than 5 per cent is claimed for $\lambda > 1/6$, it may often be useful.

Fourthly, the author discusses the non-linear properties of semiconductors which have led to their applications as circuit elements, and which are largely responsible for the widespread interest in the whole field. Dr. Ehrenberg has here made a serious effort to give an account of these developments, and has devoted more than a quarter of the book to them (108 pages). He discusses barrier layers and rectification, excess and minority carriers, their life-times, and various types and aspects of transistors. But space considerations clearly did not allow him to discuss the more complicated flow and space charge regimes in transistors.

Because the book is so broadly based, and because the author has read so widely, this is a most useful book which beginners as well as workers in this field will want to possess. The beginner should note that he has not really wasted his time when, after diligent study to p. 33, he reads "The absurd result obtained here indicates therefore a serious misapplication of the model" or when doubt is again thrown (on p. 81) on the preceding work. It might have been simpler if the author had started with what he regards as a satisfactory model (Chapter 5), and if he had introduced those results of Chapters 2–4 which are in fact needed at the appropriate points in the discussion of this model. This would have obviated the two revisions of the model in the first quarter of the book.

Although the preface is dated January 1958, internal evidence suggests that the manuscript itself was completed by 1956. When a subject develops as rapidly as the one here under review, and when the author has evaluated a great deal of recent information, a delay of two years before publication is achieved must be a matter of regret. In spite of this handicap, this book is one of the most balanced and thorough accounts of this field which is at present available.

P. T. Landsberg

PROGRESS IN PHYSICS

Reports on Progress in Physics Vol. 20 (1957). Pp. iv+568. Vol. 21 (1958). Pp. iv+383. Edited by A. C. Stickland. (London: The Physical Society, 1957, 1958.) Each 63*s*. net.

WITH the increasing pace of scientific research, the collection of information regarding recent advances in any specialized branch of investigation is a formidable task and the demand has therefore grown for detailed progress reports and review articles.

The Physical Society, as long ago as 1934, foresaw the need, and the series of annual "Reports on Progress in Physics", which the Society has published almost regularly for the past twenty-odd years, is now a well-established part of our scientific literature and has reached a standard of perfection which many more recent publications are striving to imitate.

Vol. 20 (1957) and Vol. 21 (1958), the two most recent issues in the series, each contain nine independent articles dealing with various aspects of theoretical, experimental and technological physics. The emphasis seems to be, perhaps unavoidably, on theoretical and nuclear physics. The standard of reporting is high and the authors are all experts on, and actively engaged in, the subjects they discuss. The articles vary considerably in length, not always in proportion to the importance of the topic discussed. Vol. 20 contains a long report of 140 pages by R. H. Dalitz on K-mesons and hyperons, and Vol. 21 one of the briefest, a 21-page review by D. M. Brink on the theory of collective excitations in nuclei. Every report is accompanied by a very comprehensive list of references.

All research establishments and many research workers are bound to possess their own individual copies of the "Reports". In addition, doubtless many have also purchased separate copies of particular articles, for these are available in paper covers for purchase at appropriate cheap rates. It is therefore not worth while to discuss in detail in this review the contents of the two volumes, but some general comments and reference to one or two articles may be of value. The editors of the "Reports" have in the past impressed on their contributors the necessity to bear in mind the more general reader in addition to the specialist worker, and therefore to preface their articles with an adequate introduction suitable for the non-specialist physicist and to explain fully and simply all terminology and methods used. Not all succeed in doing this, but it is pleasant to report that in the two volumes under review considerable improvement in this respect has been achieved. One or two articles in each volume have an especial appeal for the general reader. In Vol. 20, for example, the review of methods of high-speed photography by J. S. Courtenay-Pratt is both instructive and enjoyable reading, largely because of its numerous illustrations and clear diagrams but also because of the wide application of the new methods in both research and industry. Similarly, in Vol. 21, the report by R. Fatt on the physics of nerve processes, though perhaps not so easy to read, will attract the attention of the physiologist and biologist in addition to the physicist, and the detailed discussion by W. Lochte-Holtgreven on the production and measurement of high temperatures (with an addendum by R. Schall and F. Wecken on high temperatures obtained with chemical reactions), based mainly on the study of thermally excited plasmas with temperatures within the range 10,000–70,000° K., must inevitably have a wide appeal in these days.

Nuclear, atomic and theoretical physics are indeed well represented; but that does not mean that the classical physicist is neglected. For the classical physicist Vol. 20 provides an article by E. R. Dobbs and G. O. Jones on the theory and properties of solid argon, and for the solid-state physicist, "Microwave Properties of Solids" by D. M. S. Bagguley and J. Owen. In Vol. 21, the article entitled "The Specific Heats of Metals at Low Temperatures" by D. H. Parkinson affords a clear and modern treatment of a subject which has been studied extensively since the beginning of the century. During the past decade, moreover, there has been a great deal of activity in the field of low-temperature calorimetry, and most metals now have been examined in reasonable states of purity at temperatures extending into the liquid-helium range. Specific heats, like most thermal properties, are difficult to determine experimentally with precision, and the specific heat of a substance, being a macroscopic quantity, can give only limited information regarding the finer structure of matter. Nevertheless, the general theory of the specific heat of metals which takes into account the contributions of the specific heat from both the crystal lattice and the conduction electrons, and the thermodynamic derivations governing the specific heat of superconductors, are sufficiently straightforward to be within the grasp of honours-degree students of physics. Hence, not only is Dr. Parkinson's report valuable as a stimulant to the research worker to continue investigations in the field of low-temperature calorimetry of metals and in particular in the determination of the shape and position of the Fermi surface, but it is also an important addition to the text-book discussions of specific heats suitable for the advanced or honours course.

In conclusion, it should be mentioned that in addition to its nine reports, Vol. 20 contains a cumulative author index and cumulative subject index to Vols. 16–20 inclusive. S. WEINTROUB

ORGANIC FLUORINE CHEMISTRY

Aliphatic Fluorine Compounds

By A. M. Lovelace, Douglas A. Rausch and William Postelnek. (American Chemical Society Monograph Series, No. 138.) Pp. x+370. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 100*s*. net.

THE stated purpose of this book is to give complete coverage of all known aliphatic fluorine compounds and to review them comprehensively—a difficult task in this large and rapidly growing field of chemistry. It can be said immediately that this book does not provide the balanced, critical and comprehensive treatise on organic fluorine chemistry that is so badly needed at the present time. The "286 different methods of preparation . . .", "over 60 tables . . .", "physical properties of over 4,500 organic fluorine compounds . . ." summarized in the book are undoubtedly useful; but there is little of the claimed "critical review of the field's systematic progress". The book is a compilation of abstracts of papers and suffers accordingly, summarizing the factual information without propounding the basic reasons underlying the whole field.

The literature is covered thoroughly to 1955, and some 1956 papers are included. The allocation of space among the thirteen chapters (fluorination; alkanes; alkenes and alkynes; alcohols; ethers; ketones, etc.; acids; acyl halides; esters; nitrogen compounds (I); nitrogen compounds (II); organometallics; sulphur compounds) is good and the number of literature references is excellent. The book is well set out and well printed, but in this first edition there are far too many factual, typographical, and proof-reading errors, and clear signs of inadequate checking with the literature; one gets the impression that more use was made of abstracts and a card index system than of the original literature.

Typical errors are as follows: "The bromination of $CF_3CH:CH_2$ at 140° yielded $CF_3CHBrCF_2Br$ and the addition of bromine to $C_6F_7CH:CH_2$ . . . yielded $C_6F_7CHBrCH_2Br$"; ". . . where fluorination of hexafluorobenzene yields $C_6F_6Cl_2$"; "Henne and Zimmer isolated CF_3COOBr and CF_3COOI . . ."; "Roylance, Tatlow and Worthington reacted *o*-dichlorobenzene with CoF_3 and $LiAlH_4$ in ether at 0°"—fortunately they did not, and so live on.

Criticism is always easy, but the presence of numerous errors makes the book difficult to read and often misleading, particularly when errors in physical data occur in the tables. In some places the references are mixed up. One has thus to question continually whether what one has just read is factually correct or not, and how much weight should be given to the evidence. There is no doubt, however, that this could be a most useful compendium, and it is to be hoped that a corrected second edition will soon make its appearance.

R. N. Haszeldine

BRITISH MARINE FISHES

The Observer's Book of Sea Fishes

By A. Laurence Wells. Pp. 160+64 plates. (London and New York: Frederick Warne and Co., Ltd., 1958.) 5*s*. net.

THIS moderately priced little book will enable anglers and others to identify almost all the fishes they are ever likely to meet in British seas, and from that point of view it is a useful addition to a pocket series designed to serve the needs of amateur naturalists and other observers of the things, natural and artificial, among which we live. At the price it may have been impossible to provide an entirely fresh set of pictures, and most of those here were first presented to the public by the same publishers in 1925, in "Fishes of the British Isles" by J. Travis Jenkins. They were not new then, for they were taken from the well-known works of Day (1880–84), Smitt (1892–95) and others. Perhaps it is just as well that a complete set of original illustrations was not attempted, if the unfamiliar (apparently new) coloured pictures on Plates 25 and 36 are fair samples of what might have been. The crude picture of the opah will yet serve for identification, but the misrepresentations of what purport to be corkwing and ballan wrasses will not. The figure labelled corkwing bears but little resemblance to the real thing, while that named ballan wrasse is a travesty of a beautiful fish; it looks as if it might be a copy at second or third hand of the ballan wrasse in Jonathan Couch's four-volume work (1862–65).

The classification and nomenclature are modern but accounts of habits and life-histories are all too often ancient, the author seemingly having derived information too freely and uncritically from Couch (excellent as he was for his day) and other authors of the latter half of last century and the early years of this: he appears to be unfamiliar with much modern work. A few hours in a good library searching through the past thirty or so years of the relatively few scientific English language journals devoted to marine biology and fisheries would have saved him from repeating some hoary legends and would have provided him with much material not yet published in a popular work. Thus, for example, he would have learnt how the angler-fish does use its lure and would not have given what is surely another version of the account by Ælian as quoted by Couch, and he would have been led to modern knowledge of the migrations and breeding of the mackerel. These are but two instances among many which invite criticism.

This book is a lost opportunity, for there is no good modern book, scientific or popular, describing British fishes. There is a very real need for such a book, with authoritative text and new first-class illustrations: the present book provides neither.

D. P. Wilson

MEASUREMENT OF PERSONALITY

Personality and Motivation Structure and Measurement

By Professor Raymond B. Cattell. Pp. xxiv+948. (London: George G. Harrap and Co., Ltd., 1957.) 55*s*.

IN this monumental work, Prof. R. B. Cattell gives a detailed description of the systematic scheme which he has developed for the assessment of personality in terms of the major 'source traits'—those basic personality traits which determine characteristic behaviour and its variations in different individuals.

Three types of data have been utilized: ratings made by associates on forty-two types of behaviour characteristic such as adaptable, cautious, frank, etc.; answers to questionnaires on the same types of behaviour; and scores on a heterogeneous collection of objective tests, including tests of knowledge about interests, predictions of behaviour, perception and recall of related material, projective tests, autonomic reactions and various physiological measures. These data he has submitted to the statistical technique known as 'factorial analysis'; and he terms the factors extracted 'source traits', upon which are based the related types of real-life behaviour and test and questionnaire response. Undoubtedly he has carried out the statistical procedures with enormous care and ingenuity. Some of the factors extracted seem reasonable enough, for example, the motivational tendencies he calls 'ergs', such as 'self-assertion', 'escape', etc. Some of the factors relating to general personal characteristics are also widely recognized, for example, 'cyclothymia versus schizothymia', 'dominance versus submissiveness'; but others are more dubious. However, it is very difficult to accept the existence of some of these 'source traits' as basic personality factors, because of their apparent lack of relationship to the questionnaire and test data from which they are said to be derived. For example, 'premsia', a type of emotional sensitivity which differs from emotional integration, is related to a preference for being a bishop to being a colonel, a lack of physical endurance and a tendency to be brought to tears by discouraging circumstances. Although one can see a possible relationship between some of the personality factors and the associated objective test data, the tests require a much more thorough psychological investigation before their significance to personality can be established.

It is often difficult to follow Prof. Cattell's argument, since it lacks clarity, or to understand how he has used his source data. Though he must be congratulated on presenting a valuable outline approach to these questions, and on the range of data he has amassed; yet far more detailed experimental investigation is necessary before the existence of the 'source traits' and their inter-relationship within the personality is finally acceptable.

M. D. Vernon

A GEOMETRICAL APPROACH TO THE STRUCTURE OF LIQUIDS*

By Prof. J. D. BERNAL, F.R.S.

MOST of the vast literature on the liquid state is based on attempted explanations of experimental observations of the thermal, mechanical, and other properties of actual liquids. Compared with the progress of the molecular theories of gases and the lattice theory of crystalline solids, there has been little success in accounting for the phenomena of the liquid state in terms of the position and the known laws of the interaction of their constituent molecules. This is evidently because of the extreme difficulty of arriving at a model of the structure of a liquid which corresponds to the arrangements of its molecules and which at the same time is susceptible to mathematical computation. Most recent theories[1] are frankly attempts to adapt the known structures of gaseous and crystalline matter to the intermediate state of the liquid. They are consequently physically very implausible, whether they are the kinetic multiple molecular contact theories of Kirkwood[2], Born and Green[3], the cell theories of Lennard-Jones and Devonshire[4], the hole theories of Frenkel[1], Eyring[5] and Furth[6], or the cybotactic hypothesis of Stewart[7]. The last three indeed assume that a large part of a liquid consists of crystalline material, which is in contradiction to the essential negative property of liquids—their lack of long-range order.

Meanwhile, evidence on the actual molecular structure of liquids has been accumulating, starting with the classical work of Prins[8] and Stewart[7] based on X-ray, and now on neutron, diffraction of liquids[9], which shows them to possess only a short-range order, practically limited to molecules in the first and second spheres around a given molecule. Very little use has been made of this evidence in constructing theories of the liquid state, essentially because of its complexity—of a kind unfamiliar to theoretical physicists or chemists.

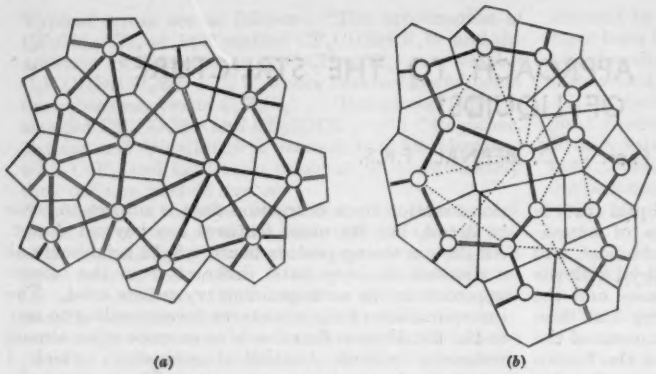
It has occurred to me recently that, in view of this and a renewed interest in the properties of liquids, it might be worth while to take up the sketch of a theory I first put forward twenty years ago[10], and to see whether it is capable of leading to a physically acceptable theory of liquids. I cannot yet claim that it is at the same time adapted to mathematical treatment, but I have hopes that at least it can be adapted to computing machines in the way that has already been used by Alder and Wainwright[11] for kinetic studies of gases.

The essential feature of this theory is that it treats liquids as *homogeneous*, *coherent* and *essentially irregular* assemblages of molecules containing no crystalline regions or holes large enough to admit another molecule. In most of what follows I shall be dealing with ideally simple liquids such as those of the rare gases (except helium), but the arguments used can apply with minor modifications to all liquids. What characterizes any particular liquid arrangement is its radial distribution function $g(r)$ which expresses the probability of finding a molecule at a distance r from any other. The determination of the distribution function from diffraction data is subject to error in detail, but its main features are beyond doubt. All show a strong peak indicating 8–12 neighbours at a distance r_0, very little different from the closest approach in the corresponding crystalline solid. The interpretation of the structures corresponding to any radial distribution function is an exercise of an almost unknown subject, 'statistical geometry', which I recommend to mathematicians. There must be theorems limiting the possible forms of distribution functions of any array of points whatever. For example, in a dense irregular assembly, each point is linked in general by fourteen vectors to its neighbours, while only six are needed to fix its position precisely, each vector being counted twice. It would be most desirable to find the true minimum number of parameters or parametral functions defining the statistical structure of any homogeneous irregular assemblage in the way that the lattice vectors define a regular one. I suggested—but could not prove in my original paper—that three parameters suffice to determine the whole of a distribution function: N_1 the number of neighbours, r_1 the mean distance, and λ_1 the variance of r between the neighbours. Whether this be so or not geometrically, it is evident that physically most of the properties must be determined by the arrangement of neighbouring molecules, on account of the rapid fall-off of attractive intermolecular potentials as $1/r^6$ for apolar molecules.

What I am attempting to do now is to examine more closely the neighbour relations in irregular assemblies of molecules. In any definite assembly of points whatever, the neighbours of any one point can be precisely indicated. If planes are drawn bisecting the distances between each point and any other, then we can call those points corresponding to the sides of the smallest convex polyhedron surrounding the point the *geometrical neighbours* of the point[17]. There seem to be, in irregular as in regular arrangements, some fourteen of these, and in any approximately dense assembly of molecules, they will lie between r_0 and $\sqrt{2}r_0$, where r_0 is the distance of closest approach. In the ball-and-spoke model (see below), this number was found to be 13·6 and in the 'Plasticene' model 13·3.

Many of the properties of liquids can be most readily appreciated in terms of the packing of irregular polyhedra—as in a foam (Fig. 1). For example, the total volume V of a liquid of n molecules is Σv_q, where v_q is the volume of the q^{th} molecular polyhedron. To obtain an expression for v_q, or rather for $\bar{v}$, the mean polyhedron volume, in terms of molecular dimensions and arrangement, it is not convenient to use the number of geometrical neighbours, which is insensitive to these factors. It is easier to use the number N of *physical neighbours* which can be defined, arbitrarily, as those of the geometrical neighbours which lie at distances between r_0 and $5/4\ r_0$ (for beyond the latter distance the Van der Waals attraction falls to less than a quarter of its maximum value). The mean volume can then be expressed as $r_0^3 f(N)$, where $f(N)$ is a function not yet

* Substance of a Friday Evening Discourse at the Royal Institution on October 31.



(a) (b)

Fig. 1. Diagram of neighbourhood polyhedra, geometrical and physical, for two-dimensional arrays of points. (a) High co-ordinated; —, physical neighbours; (b) low co-ordinated; ...., geometrical neighbours

determinable for the case of irregular packing, but which cannot differ widely from its value in regular packing as shown in Table 1.

Table 1

N	12	10	8	6	4	3
$f(N)$	5·66	5·9†	6·4†	8	12·3	18
$f(N)/f(12)$	1·0	1·04	1·16	1·41	2·17	3·18
T^*	0	0·8	0·9	1·0	1·2	1·27
		T_m				T_c

† Interpolated values

The equivalences of N with reduced temperature T^* are derived from de Boer's results (ref. 20).

The irregularity of the neighbourhood polyhedra is the essential condition for liquid as against crystalline structures. It can be seen to underly their thermal and mechanical properties. It implies first of all the absence of long-range order and of symmetry other than statistical. The conditions that a set of quasi-equal irregular polyhedra must satisfy to fill space completely must be stringent, but I have not been able to define them mathematically. Instead I have tried to approach them by physical and mathematical model-building in a somewhat different way from that employed by Morell and Hildebrand[18]. In the first place, I have constructed models of balls and spokes as irregular as possible using spokes of lengths from 2·75 to 4·0 in. in the proportions roughly the same as observed in liquid distribution functions (Fig. 2). From such models it is possible to draw conclusions on volume and energy of the corresponding arrangements of actual molecules. I have also built models from which the human element is eliminated so far as possible by 'Monte Carlo' constructions. The first of these which I attempted ten years ago was purely mathematical. I operated on a pseudo-lattice with a possible cell content of 100 unit spheres in close-packing. Into this I inserted such spheres in random positions, rejecting all those that would foul earlier positions. After inserting less than fifty spheres there was no room for another. Hence the volume per molecule was more than twice that in close-packed arrangement. This led me to abandon the effort, for it was clear that this random-packed assembly could not be the model of a liquid of volume only 10 per cent more than close packed. I see now it was the model for a liquid approaching its limit of coherence at, or above, the critical point.

The second 'Monte Carlo' approach I have tried with physical models is analogous to the formation of irregular close-packed liquids by compression from a gas. A set of points is chosen at random in the large cell of a two- or three-dimensional lattice (Figs. 3 and 4). If these are thought of as being rigid spheres of unit radius, the compression of such a cell is exactly equivalent to expanding a sphere surrounding each point. No new points are added. Starting with the nearest pair, the points are moved apart by small successive stages so that at each stage no two points are nearer than a pre-specified distance. There is a limit to the process, however. At a length corresponding to about 0·9 of the close-packed distance in two dimensions and 0·95 in three dimensions, no further movement is possible without introducing long-range order. In other words, at densities beyond a certain limit, only crystalline arrangements of incompressible spheres are possible. Two-dimensional

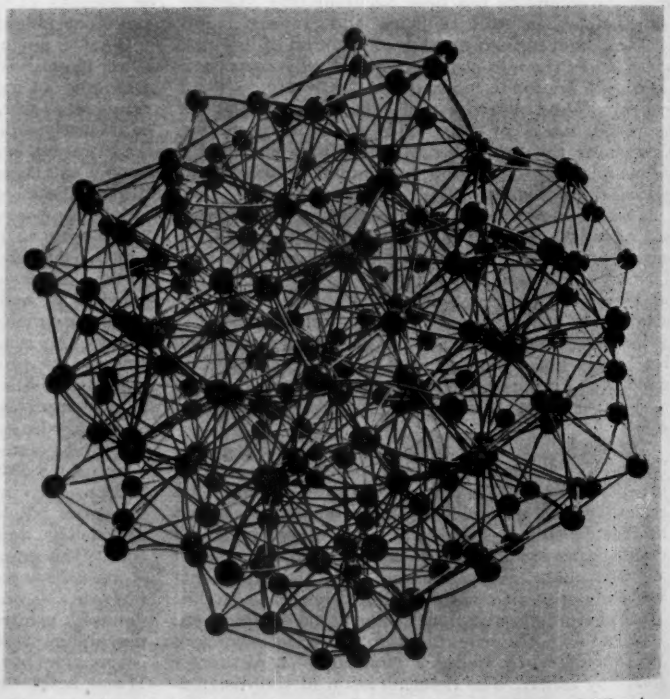


Fig. 2. Photograph of ball-and-spoke model of irregular structure. Spokes of different length are distinguished by colours

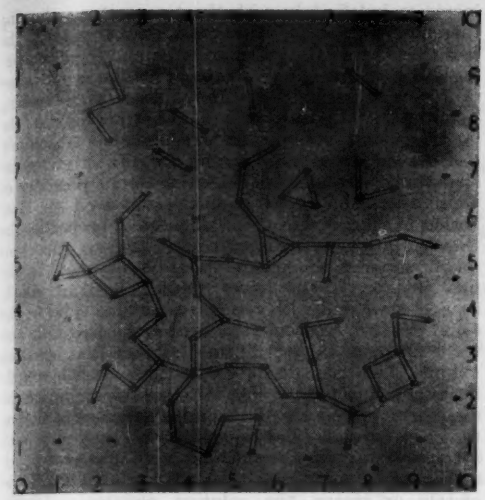


Fig. 3. Two-dimensional random/crystal model at intermediate stage. No two points are at a distance smaller than the 8-cm. long links joining most of the points

aggregates crystallize more easily than do three-dimensional aggregates. This is a point of the greatest importance, because the possibility of irregular co-ordinations are multiplied in three dimensions. The whole process of compressions can be carried out by rules adapted to the iterative action of an electronic computer; but this has yet to be done, and it may turn out to be blocked by the occurrence of impossible moves or 'moving corner' ambiguities. However, enough has been done to bring out clearly that indefinite irregular assemblies can be constructed having about the same volume, internal energy and distribution function, as tested by the Lipson diffractometer, as simple liquids. The possibility of forming such statically stable, dense irregular molecular aggregates in three dimensions follows indeed from the great variety of polyhedra of 10–14 sides that can be escribed about the same sphere. Such arrangements, though they must have slightly greater energy than the corresponding regular assembly, are so much more numerous as to provide for greater entropy.

I have also attempted to describe the irregular character of such distributions both mathematically and by models. I am reasonably sure that the enumeration of topologically distinct convex polyhedra having in general three edges meeting at a point must have been carried out by some mathematicians, though I cannot trace it. The subject

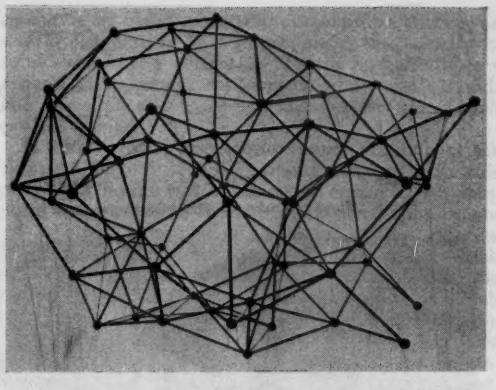


Fig. 4. Three-dimensional hanging-ball model at intermediate stage

appears not to be of interest to modern mathematicians, and I have found little on it later than Cayley[13] and Kirkman[14], who were only interested in symmetrical solutions, except in the very valuable studies of Toth[15]. The derivation of the irregular polyhedra is straightforward but tedious. There are certainly 46 distinct polyhedra with up to 12 faces composed of polygons of 4, 5 and 6 edges (Fig. 5). There are probably, though I have not exhausted the list, some 150 of up to 14 faces. To work out the angles and closest approach of spheres to all these would be a formidable task. Before attempting it I thought it would be well to discover which of them were likely to occur in nearly close-packed assemblies of spheres. For this I used a rough empirical method adapted from that developed by the botanist Marvin[16] to determine the shapes of cells in plants. Balls of 'Plasticene' rolled in chalk were packed together irregularly and pressed into one solid lump. The resulting polyhedra (Fig. 6) were analysed for arrangement of their polygon faces, with the results shown in Table 2. Two results are noticeable: first, the wide variety of polyhedra—the 65 studied showed 32 different combinations of polygonal faces and only two were found with the same permutations of these faces; secondly, the absolute predominance of pentagonal faces. In all but six cases, no polygon appeared more often than a pentagon. These observations, taken together, are the key to the geometrical nature of irregular aggregates of equal spheres and also, in my view, of the molecular arrangements in liquids. Regular three-dimensional arrangements have symmetries limited to multiplicities of 2, 3, 4 and 6. Pentagonal arrangements can only occur in very complex structures such as some of the alloy structures classified by Frank[17].

Table 2. Number of Each Polygon Combination Type arranged in the Order of the Number of Pentagonal Faces

Number of pentagonal faces: 12	10	9	8	7	6	5	4	3	1
0 12 0 (2) 0 12 2	1 10 2 (4) 1 10 4 (2)	1 0 9 3 2 9 5 1	2 8 1 (2) 2 8 2 (3) 2 8 3 (3) 2 8 4 (4) 2 8 6	3 7 2 1 (3) 3 7 3 1	3 6 2 3 6 3 (5) 3 6 4 (5) 3 6 5 (3) 3 6 6 (5) 4 6 4 2	1 2 5 3 4 5 3 1 4 5 4 1 (2)	1 3 4 3 1 1 3 4 4 1 (2) 1 3 4 5 1 (3) 1 3 4 6 1 4 4 2 4 4 4 4 4 5 4 4 6	5 3 3 1	1 4 1 5
3	6	2	13	4	20	4	11	1	1

Total number of polyhedra, 65. Number of polyhedron categories, 32

Explanation: The numbers for each polyhedron are put in the order of the polygonal faces. For example, 1 3 4 5 1 stands for a polyhedron with 1 triangular, 3 quadrangular, 4 pentagonal, 5 hexagonal, 1 hepagonal face. The last row gives the number in each category.

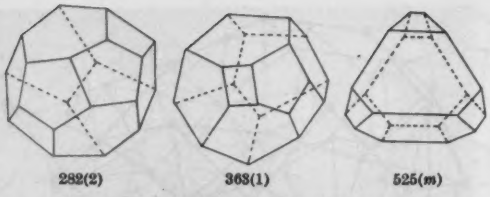


Fig. 5. Three typical polyhedra with twelve faces

Fig. 6. 'Plasticene' hemisphere showing polyhedra

My central geometrical thesis is that *irregular dense packing and pentagonal arrangements are necessarily connected*. Though I have no proof of this theorem for lack of an adequate statistical geometry, I think it is related to two simple geometrical facts: first, that twelve spheres touching an equal sphere are most regularly distributed in a way in which one just fails to touch five others in its shell—it has a surface co-ordination of 5, to follow Frank's terminology. This results in a pentagonal icosahedron, a shape which cannot be used to fill space. Secondly, in those forms which can fill space, the twelve co-ordinations corresponding to hexagonal or cubic close packing, each sphere is in actual contact with only four others in its shell, a very stable but improbable arrangement. This is on the basis of a rough examination of the number of possible arrangements of 10–15 circles on the surface of a sphere. This may be susceptible to exact statistical treatment, or could be adequately worked out on a computer.

The irregular dense arrangement occupies a volume per sphere of some 10 per cent more than close packing. This is the figure first found by Osborne Reynolds[18] in his studies of the dilatancy of close-packed sand.

I have always found it impossible to construct irregular arrangements of any intermediate density. I believe this is a necessary consequence of the irregularity, and that there is *an absolute impossibility of forming a homogeneous assembly of points of volume intermediate between those of long-range order and closest packed disorder*. Regular and irregular close packing are evidently arrangements of quite different local co-ordination, and a transition between them is necessarily as abrupt as that between two regular phases of different structure such as occurs in the α-(body-centred) and γ-(face-centred) phases of iron.

Translated into physical terms, this geometrical difference expresses the absolute discontinuity between the liquid and the crystalline phases and accordingly the need for a first-order transformation between them. This is in accord with Simon's general findings[19] that the melting entropy of solids increases indefinitely with the temperature, showing therefore no tendency towards a critical point. The fact that the polyhedra of irregular and regular packing differ only slightly in volume for the same values of N would seem to justify, at least as a working hypothesis, the idea that a liquid structure near the melting point is only an irregular but absolutely distinct variant of a crystalline one. In this irregular structure, molecules are vibrating about positions of equilibrium for times so long compared to their period of vibration that for all thermal properties the time variations of molecular positions—so important for all transfer phenomena—can be neglected in the first instance. The lower specific heat of simple liquids compared with the corresponding solid at the same pressure is accounted for by the irregular and wider shape of the equilibrium minima: at constant volume there is little difference between the specific heats of solids and liquids. On this basis, finding the equilibrium structure of a liquid is the same as finding that of a crystal. For liquids having molecules with attraction rapidly diminishing with distance—such as rare gases and organic liquids, but not for liquid metals or water—the solution equates minimum energy with minimum volume. If the internal energy U varies as $1/r^6$, it must vary as $1/v^2$, as Van der Waals had intuitively supposed. The types of irregular arrangement arrived at by all the methods described above, except that leading to maximum coherent volume, are of minimum volume and should be near to true models for a liquid near the melting point. Indeed, by using a potential function of the form $U = \frac{A}{r^{12}} - \frac{B}{r^6}$ they are found to give the right orders of magnitude for the heat of fusion.

The chief advantage that a theory based on the intrinsic irregularity of liquid structures has over most cell or hole theories is that it gives a natural qualitative explanation for the high entropies of liquids compared with solids which these theories have failed to do, as de Boer[20] has pointed out. Unfortunately, it is not yet possible to put this on a quantitative basis. The fundamental difficulty is to know what to count as a configuration in order to build a partition function. It is evident that in an irregular structure there is a wide variation in the potential energy associated with each molecule. The extent of this variation, drawn from the first model structure and from the 'Plasticene' polyhedra, is shown in the histograms (Fig. 7).

It may be possible to make use of these differences to build a partition function somewhat on the lines advocated by Kikuchi[21] for another liquid model; but even without this, we can make a qualitative picture of the energy states in a liquid as a function of temperature. In the first place, from near the melting point downwards through the range of supercooling, the approximate close-packed disorder is maintained, for it cannot change without crystallization, which, for the reasons already given, is always a discontinuous phenomenon. However, at all temperatures the thermal state of a liquid is fundamentally different from that of a solid, for the rise in temperature leads not only to higher vibrational levels, as it does in a solid, but also to changes in the equilibrium configuration, increased disorder, and, at constant pressure, also to greater volume, lower co-ordination numbers and consequently lower mean-lattice energy. A liquid, over this range of temperature, corresponds more to a series of polymorphic phases with heats of transformation between them

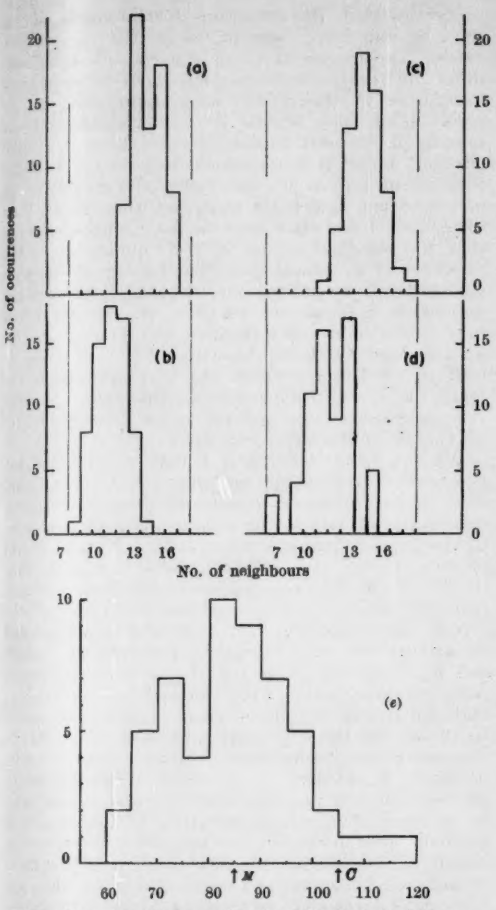


Fig. 7. Histograms of (*a*) geometrical and (*b*) physical neighbours derived from 'Plasticene' polyhedra; (*c*) and (*d*) derived from the wire model. (*e*) Distribution of energy between balls in wire model in arbitrary units. *C*, energy of corresponding crystal; *M*, mean energy of liquid

than to a single phase, as explained in my original paper[10]. Instead of heats of transformation, the process is smeared out to give an accelerated rise in the specific heat at constant pressure which I called the 'configurational specific heat'.

This has been recently studied in detail by Jones and Walker[22] for liquid argon. Their observations of the specific heat seem to me of fundamental, but hitherto unrecognized, importance. They find that, well above the critical pressure, the specific heat at constant pressure, starting at 10·8 cal./mol./deg. C., increases rapidly with temperature to values of nearly 50, reaches a sharp maximum and then falls to the normal value 3 for a gas. This is the condition for a higher-order transition (λ-point) between the liquid and the gaseous state. The line of transition in the pressure-temperature diagram continues that of the boiling-point line indefinitely beyond the critical point. I would suggest calling this line the *hyper-critical line*. Its existence shows that liquid and gas do not form, as previously thought, a single 'fluid' phase. They are distinct states of matter, though one may pass into the other without visible discontinuity. (The discontinuity is, however, 'audible', as shown by heavy absorption of sound in this region and is also shown by a minimum in the velocity of sound and in the viscosity.) This is probably a very general phenomenon applying not only to all liquids and gases but also to all critical mixtures above their critical points.

It finds a ready explanation along the lines of the theory I have just been putting forward. In this picture, a liquid will continue to expand with temperature until it is slightly more than three times its original close-packed volume. The *physical* co-ordination number falls to between 4 and 3, which is the limit for 'coherent' structure—one in which the molecules are linked together without a break throughout the whole volume (Table 1 and Fig. 8). Above the hyper-critical temperature it becomes 'incoherent', consisting of associated groups of molecules in free space. As this temperature is approached, therefore, at constant pressures at or above the critical pressure, more and more co-ordination links are broken, leading to a rise in specific heat. This falls again beyond the hyper-critical point as fewer and fewer links remain to be broken. Just below and above this temperature, the number of intermolecular links undergoes no abrupt change; hence there is no heat of transformation, but continuous regions become discontinuous and vice versa. This is analogous on a micro-scale to the sharp transition between oil-in-water and water-in-oil emulsions. At temperatures and pressures approaching the critical point, the coherent–incoherent structures become also inhomogeneous with macroscopic cavities and drops leading to the critical opalescence, the study of which has been recently taken up again by Debye[23].

The fundamental structural characteristic of liquids —the irregular arrangement of their molecules—can be seen also to be the basis of their characteristic physical property—their fluidity. In a way impossible for a crystalline solid, the neighbourhood relations of molecules in a liquid are necessarily in continual flux. This is easiest to understand by considering the relationships of the polyhedra which define the closest interacting neighbours. The elementary process by which a molecule loses a neighbour is represented by the closing in of the face common to both; how it gains another is by the opening up of a new, in general, triangular face (Fig. 9).

Such processes must occur constantly by thermal motion on account of the sustained inequality of energies between molecules. By repetition they give rise to self-diffusion and show themselves on the macroscopic scale in fluidity. In this view, the *fluidity of a liquid is a consequence of its molecular*

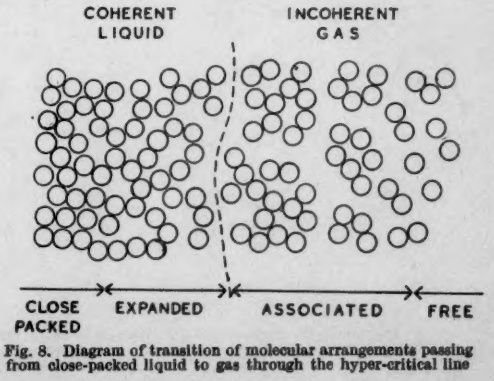


Fig. 8. Diagram of transition of molecular arrangements passing from close-packed liquid to gas through the hyper-critical line

irregularity and not vice versa. The construction of a theory of viscosity based on such a mechanism would be formally almost identical with that of Eyring[6], based on the hole theory and the analogy to rates of chemical reaction. Another consequence of the intrinsic irregularity of liquid structures is their powers of accommodating molecules of different sizes, and consequently accounting for the solvent powers of liquids and their mutual miscibility.

This picture of the liquid state, based on the properties of the simplest spherical molecules such as those of the rare gases, is readily extended to other types of liquid. It can take into account the effects of shape, as in most organic liquids (for example, it would explain the quasi-crystallinity of two-dimensionally packed long-chain hydrocarbon molecules); the presence of hydrogen bonds, as in water, alcohols and acids, leading to the formation of non-equilibrium liquids or glasses; the presence of oppositely charged ions, simple or complex, as in fused salts where low co-ordination[24] also leads to glasses; and that of free electrons, as in metallic liquids where, as I have already proposed[25], the metal ions occupy a smaller part of the volume, leading to greater fluidity and smaller change of volume on melting.

This theory, or rather sketch of a theory, of liquids is put forward not because it accounts better for their properties than the numerous formal mathematical theories that have been in use in the past twenty years. The success of many of these, often radically different from each other, only goes to show how insensitive to theory are such expressions as the equation of state or the laws of viscosity. I am putting it forward rather because, as a crystallographer, I find it more satisfactory to try to build theories of liquids on the basis of a model of an instantaneous molecular structure that is at least plausible. I feel that we now have ample evidence that the essential nature of the liquid state is the existence of statistical molecular configurations with varieties of co-ordination patterns geometrically necessarily different in kind from any that can occur in a regular solid. Any theories that do not take this into account—and few have hitherto—are likely to lead to predictions which are the wider from the facts the more the properties concerned, such as vapour pressure or critical constants, depend directly on the molecular arrangements.

What I have done, and I hope even more the programme of research that should follow it, should show that an approach to a theory of liquids based on irregularity is not so formidable mathematically as to discourage quantitative studies. If this should prove to be the case, it seems probable that the new theory should not only explain known facts but also point the way to unsuspected new phenomena.

Note added in proof: Prof. F. C. Frank has directed my attention to the important papers by C. S. Smith[26] and L. J. Meijering[27] on the shapes of crystals in a polycrystalline solid. The former, by experiment, finds the average number of geometrical neighbours to be 12·48; the latter calculates, by an elegant method, that for a completely random distribution of nuclei it should be $48/35\pi^2 + 2 = 15{\cdot}54$. This is clearly greater than the numbers observed and would seem to indicate that the distribution of nuclei is not random. This, however, does not affect the argument above, for the *average* number of edges on the faces of such polyhedra only varies from 5 to 5¼ when the number of faces changes from 12 to 16. An alternative version of the general thesis of the paper could be put in the following form:

"In the most probable arrangements of densely packed spheres the *mode* of the surface co-ordination will be the same as the *mean*, or nearly 5. As this

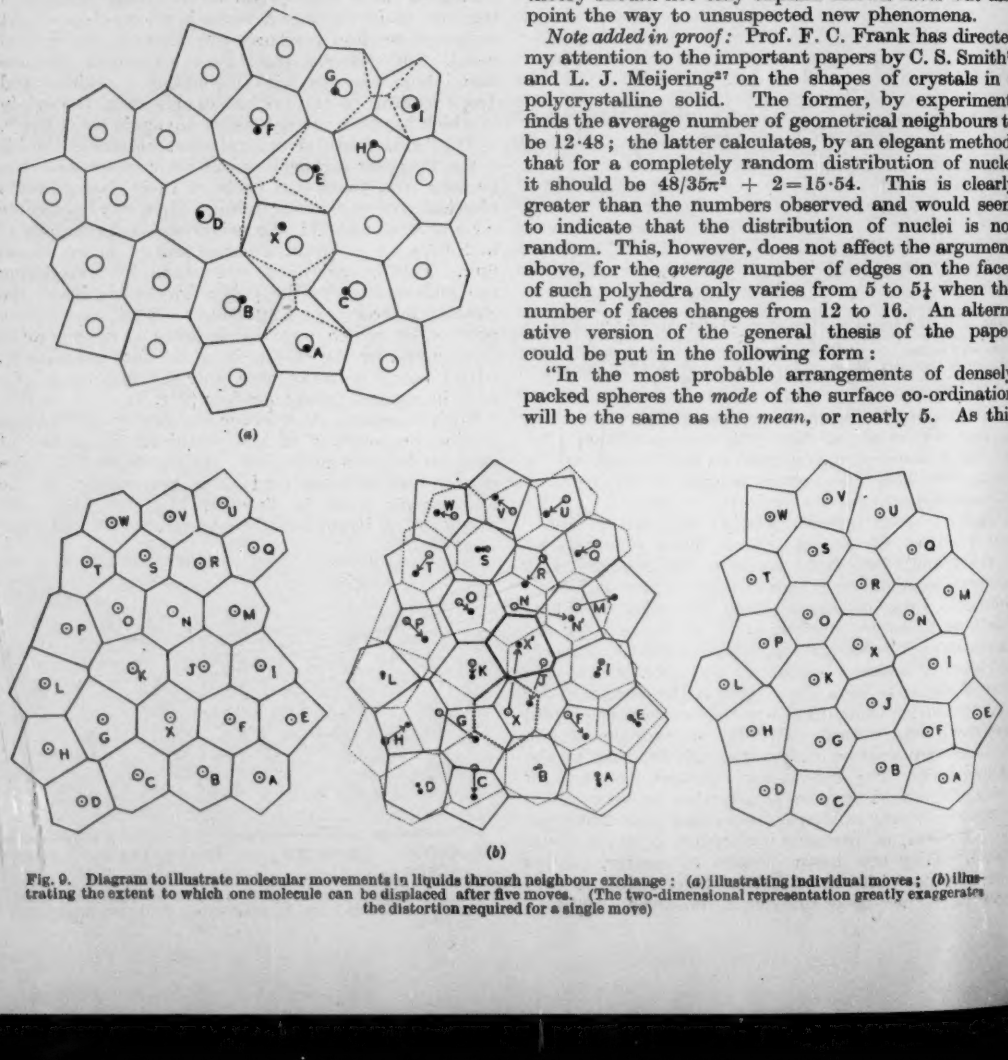


Fig. 9. Diagram to illustrate molecular movements in liquids through neighbour exchange: (*a*) illustrating individual moves; (*b*) illustrating the extent to which one molecule can be displaced after five moves. (The two-dimensional representation greatly exaggerates the distortion required for a single move)

is incompatible with long-range order, the corresponding arrangement of molecules must be a fluid."

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INTERNATIONAL CONFERENCE ON SCIENTIFIC INFORMATION

THE National Academy of Sciences–National Research Council in Washington was co-sponsor with the U.S.A. National Science Foundation and the American Documentation Institute in arranging an International Conference on Scientific Information during November 16–21 in the Mayflower Hotel, Washington. The Conference opened with an address from Sir Lindor Brown, biological secretary of the Royal Society, and this was followed by a series of sessions, each of three hours, devoted to a section of the Conference subjects. The purpose of the Conference was to bring together scientists and information specialists for discussions of current research and problems concerning primarily the storage and retrieval of information. This is a narrow scope compared with the Royal Society Conference on Scientific Information Services held in 1948. Nevertheless, preprints of seventy-five papers occupying 1,420 pages were circulated to all participants some weeks before the Conference. These participants numbered about one thousand, and for the purpose of facilitating discussion the authors and members of seven discussion panels, each of 9–13 persons appointed well in advance of the meeting, were grouped in a forward section of the Conference hall and permitted to comment throughout the meeting. The remainder of the participants were silent observers during the sessions, but there was ample opportunity for discussion outside the Conference hall and in the neighbouring hall, which housed an exhibition of modern storage and retrieval systems devised by commercial organizations. A small historical exhibit illustrating the Royal Society's long and continuing interest in scientific information services was also on view. Arrangements were made for organized visits to institutions in Washington concerned with the retrieval of information. These included the Library of Congress, the U.S. Patent Office, the National Bureau of Standards Data Processing Systems Division, National Library of Medicine, the Department of Agriculture Library and the Institute of Languages and Linguistics of Georgetown University, where a machine translation of Russian texts in organic chemistry using an I.B.M. 704 computer was demonstrated.

Sir Lindor Brown in the opening address directed attention to the desirability of discipline and restraint on the part of the authors of scientific papers. He said there is much scientific literature which need never be produced, and of that which justifies its appearance 80 per cent could be improved by drastic reduction in length and by clear writing. He urged scientists to publish the results of their work once and once only, and not in a multiplicity of guises. He went on to say: "However we improve the raw material of information there will still remain poor papers, unnecessary papers, trivial papers and repetitious papers. What are we to do with them? What is to be stored? Is it the fruit of the tree of knowledge or is it the fallen leaves? For my part I should be happy if the fruit only were preserved, as I cannot conceive of any collecting and storage system adequate to cope with the world's output of scientific information as it grows at present, and I view with only a little compunction the prospect of the loss of minor contributions to knowledge provided that the ripe fruit can be preserved. The few fallen leaves of my own work are already losing their individuality as they dissolve into the rich compost of the background knowledge of the rising generation. Their individuality is lost, but they have contributed a little to the vigour of the pushing young shoots at the top of the tree—and of course I have a fruit or two up my sleeve still. Of course we have the difficulty: Who is to decide what is the fruit and what is the fallen leaf? Can any information service work on an eclectic principle? I think it can. But only with the full co-operation of the user and the maker of information".

As mentioned above, the primary purpose of the Conference was discussion. No attempt was to be made to arrive at conclusions in the form of recommendations. The Conference certainly achieved its objects of exposing the problems of retrieval of information and of bringing the interested parties together. Although each panel was at liberty to deal with its subject in its own way, the general procedure adopted was to assume that the papers had been read; the panel members then commented on the subject, referring to papers as desired, and a period of general discussion followed.

Panel 1 concerned literature and reference needs of scientists. The papers chiefly related to surveys of information requirements of scientists in a variety of different research organizations, and methods by which research workers find information. A fact brought out by the papers was that communication of scientific information is done as much through personal conversation as by reading the literature. It was stated that the volume of scientific literature is doubling every seven years. It was evident that it is impossible to make generalizations in methods of communicating information and that not only do methods vary from subject to subject but also from user to user and according to the uses to which the information is to be put. Studies on the habits of scientists in acquiring information are still imperfect, but may be the bases for action in certain local situations. The present services go a considerable way towards meeting the needs of the competent research worker in his own field, although the use of abstracts seems to be on the decline and the research worker is not so well served when he wishes to explore a field other than that with which he has some familiarity. The importance of the unplanned contact with new scientific information was stressed.

A plea was made for more studies of the physiological nature of recognition and memory. One contributor urged that neurones as well as electronics have a role in the retrieval of information. Reading-rates of students of about equal standard were reported to vary from 2·5 to 9·8 words a second, and further studies on this and the related problem of reading and visual fatigue were suggested as a fruitful field of investigation.

The second Panel discussed the effectiveness of abstracting and indexing services. The discussion reploughed familiar ground in relation to authors' abstracts versus non-author abstracts, informative abstracts versus indicative abstracts, the role of highly centralized general abstracts (as in Moscow) and specialist abstracts (as in the Commonwealth Agricultural Bureaux), and little that was new emerged. One study, however, reported that in spite of all that is said about biasing abstracts for particular classes of readers, there is a growing tendency by many abstracting agencies to use authors' abstracts. There seemed to be a generally favourable opinion that if authors' abstracts are properly edited they can be of considerable service, and the action taken by the Abstracting Board of the International Council of Scientific Unions in encouraging this in physics abstracting was supported. On the other hand, the delays in issuing some abstracts is becoming so great that in rapidly developing subjects they are of little use for current awareness, and alternative means, for example the quick circulation of the titles of papers as in *Current Chemical Papers*, will have to be investigated. The importance of indexing was stressed by Dr. E. J. Crane, of *Chemical Abstracts*, and in commenting on the possible use of mechanical aids in abstracting he warned against the danger of departing from existing high standards in abstracting and indexing.

The third Panel was concerned with the effectiveness of monographs, compendia, and specialized centres. Some time was devoted to discussing reviews, and it was generally agreed that an insufficient number of first-rate people are willing to give time to their compilation for the benefit of a variety of users—the specialist, the specialist in related fields, the teacher and general reader. The suggestion was made that review writing should be a joint effort of a junior who did the searching of the literature and an experienced scientist who would provide the necessary critical judgment. The review should preferably deal with concepts and leave data to special compendia. The writing of monographs seems to be going out of fashion, although it remains important in biology. An experiment in the U.S.S.R. was described where the Institute of Scientific Information plans to issue a series of monographs attempting to cover the whole field of science: the Russian definition of a monograph is a scientific work which concentrates and develops all aspects and facets of a given scientific discipline and requires strict objectivity from the author. The chief difficulty will be the shortage of suitable authors.

Dr. E. Pietsch, director of the Gmelin-Institut, Germany, described in detail the organization of the "Handbuch für der Anorganische Chemie", where the evaluation of the data is by far the most costly operation in preparing the text. The eighth edition will consist of 60,000 pages and will cover two hundred years of the subject up to 1950. If the "International Critical Tables" were to be re-issued on the same lines as twenty-five years ago, it might require several hundred volumes. The issue of abbreviated tables of data in the form of handbooks for specific uses was strongly urged, and a suggestion was made for increased use of directories of scientific workers and their interests to assist the communication of information. There was also some discussion on the increased use of technical reports, only a fraction of which, however, is abstracted in the abstracting journals because the editors of the latter consider the technical report to lack the careful preparation imposed on the writing of a paper for a journal and because a report, or part of it, is liable to be published again as a paper. The need to give greater emphasis to the value of books in information services was stressed.

A variety of national scientific information centres were described; for example, those in the U.S.S.R., India, France, Japan, Czechoslovakia and Poland. A novel feature of a Czechoslovak service is that all inquiries must be made by telephone, as it is thought that only by this means can the inquiry be sufficiently well defined by discussion to make the information service really efficient. The Soviet representative advocated the centralized information centre and quoted Vavilov as saying that "the contemporary man of research is in the same position in relation to the holdings of libraries of the world as the gold prospector faced by the jungle". The centralized institute dealing with national and international scientific literature was adopted in the U.S.S.R. because all knowledge is organically interconnected, and in one institute, where are concentrated specialized personnel, all collective data, etc., knowledge from one field, for example, physics, can be readily related to other fields such as chemistry, biology, metallurgy. In Poland, where there is an information service in applied science, only the central direction is concentrated in Warsaw and a decentralized system, using eighty different regional institutions and a hundred or more industrial centres, is found to be effective in providing an organized person-to-person contact.

Panel 4 considered the organization of information for storage and search, and devoted some time to the comparison of the characteristics of existing systems. It was considered that, at present, each specific

problem requires a system tailored to the special demands on it and the need for further experiment was admitted. Where machines have been used, it seems too early to generalize on their merits or demerits, and consideration of the replacement of the human brain by a machine in a system of retrieval only emphasized the need for any machine to have a good master.

Panel 5 discussed the organization of information for storage and retrospective search. There were twenty preprinted articles in this section, many dealing with the classification or coding of information in specialized fields, in such a way as to enable mechanical retrieval. Words were regarded as being too imprecise for large-scale mechanical information retrieval, and it was suggested that a rigorous mathematical theory of systems should be sought for future development. Further study was proposed of language and the nature of communication—a multi-stage process with the interplay of ideas in a highly unorganized state. In the meantime, the solution of narrow practical problems seemed the more profitable line of advance. Even with a high-speed machine of long memory, the intellectual problem of searching the literature will remain. Machines require careful programming, and it was stated that all they can achieve is to do clerical work more quickly.

Panel 6 concerned itself with the possibility of a general theory on the organization of information for storage and retrospective search. This gave rise to a great deal of discussion, and for those who are expert in one or more systems this may well turn out to have been a profitable occasion, for it appeared that no existing theory can be directly applied, and much more experiment, discussion and thought will be necessary before a general theory can be evolved. The greatest difficulty is to provide for the interaction between the inquirer and his information sources; thus, any general theory must accommodate the learning process and the consequent need to modify itself continuously. It seems likely that, with so much interest in the subject, something constructive may emerge within the next few years.

Panel 7 covered a wide range as it discussed the responsibilities of governments, scientific societies, universities and industry for improved information services and research. The Panel took an early opportunity of pointing out that the only indispensable person in the whole subject is the scientist, and that through his societies he is the principal maker and user of scientific information. Scientific societies should, if possible, be self-supporting in the publication of original work, but any help required in the secondary information services should have government support, as scientific information is a national resource. As a user, the specialist usually organized his own search, and it was suggested that universities might encourage, more than is done at present, young research workers in learning how to use the literature of their subject as well as how to produce it by the better writing of their papers. Scientific societies might encourage authors not only to submit abstracts but also provide key index words to facilitate the editing of abstracts and indexing.

Nowadays some national governments are large-scale users and producers of information and have responsibilities for its proper distribution. This varies from the small country with a relatively recent acquaintance with scientific research, where information services receive their main support from international agencies, for example, from Unesco through a regional office, to large scientifically advanced countries where national funds are provided on a large scale and where government agencies provide a plan for stimulating and supporting scientists and engineers in dealing with information problems. Whatever method is employed, the wholehearted co-operation of those who produce the information is necessary.

In the international field the work of the Abstracting Board of the International Council of Scientific Unions was cited as a good example of co-ordination of existing services. The Panel was not in favour of trying to establish an international scientific information centre at present, but rather favoured the co-ordination of national services, for example, through national library services. The trend should be towards more national centres and more international co-ordination. A statistical survey of the economics of the various types of national centres would be helpful in this connexion.

There were no formal conclusions of the Conference, but hopes were expressed that some more formal international organization might follow, possibly through national academies of sciences. Whether this happens or not, the participants in this International Conference on Scientific Information were stimulated by attending it, and it will not be surprising if they in turn stimulate further action towards a renewed consideration of the many and growing problems of scientific information services in their respective countries. That those concerned in the United States are active is obvious.

D. C. MARTIN

OBITUARIES

Sir Hubert Wilkins

THE death occurred in New York early in December of Sir Hubert Wilkins; he was seventy years old. He will be remembered as a pioneer both in arctic and in antarctic travel.

Wilkins first visited the Arctic as second-in-command of Vilhjalmur Stefansson's Canadian Arctic Expedition which went north in 1913. Wilkins remained a member until 1917 and during these years he became expert in travel on arctic pack-ice. He himself, however, was always keener on air travel and was probably the first man to fly in the Antarctic. His flights in the Arctic, after more than one attempt, culminated in 1928 in an adventurous journey from the north of Alaska to Spitsbergen, for which he received the Founder's Medal of the Royal Geographical Society. His arrival in the latter region stirred the people of Great Britain as no other arctic flight had done. He wrote an exciting dispatch describing the journey for *The Times*; it was one of the best travel reports ever written.

An important feature of Wilkins's explorations was his work as a naturalist. He made collections in Australia; and he joined Shackleton on the *Quest*, for example, as a collector of natural history specimens. Wilkins was also in the Antarctic with

J. L. Cope in 1921 along with T. W. Bagshaw and M. C. Lester.

One of his most spectacular proposals, however, was his putting forward the idea of taking a submarine under the arctic pack-ice, and by the effort which he made with Lincoln Ellsworth in 1931 he was thus anticipating the successful voyages made by a later *Nautilus* in 1958.

One of Wilkins's earlier associations with Lincoln Ellsworth had led to an important flight across a sector of Antarctica in December 1928. On this occasion a message reached Britain from Wilkins, who was on board ship, that Ellsworth had got into difficulties after reaching the edge of the Ross Barrier together with his pilot, Ben Eielson. This led the British Colonial Office to arrange that the *William Scoresby* should be diverted at short notice to the Antarctic, and Ellsworth and Eielson were picked up without difficulty.

Wilkins, on these flights in December 1928, had stated that Graham Land was insular. This led to much confusion at the time and attempts to identify places in Graham Land such as Stefansson Strait and Crane Channel. The matter was not cleared up until the Rymill Expedition began surveys in 1934. Wilkins had, in fact, regarded as straits what in reality were glaciers. At the time, however, Wilkins's claims to have discovered 'Hearst Land' and 'Stefansson Strait' were a source of controversy.

Hubert Wilkins was one of the earliest explorers of the air age, and his picturesque figure with his short, trim beard made him well known and popular in the United States, where he had made his home.

J. M. Wordie

Prof. Florence A. Mockeridge

Florence Annie Mockeridge, emeritus professor of botany in the University College of Swansea, died on December 18 at the age of sixty-nine.

Florence Mockeridge studied first at Woolwich Polytechnic (Penfold gold medallist) and then at King's College, London, as a Merchant Taylor's Company Scholar. She graduated with first-class honours in the Pass B.Sc. in 1909 and again in the Honours B.Sc. in 1910 and was awarded the Carter Gold Medal of King's College. During 1911–17 she undertook research with Prof. W. B. Bottomley, first as a Layton Research Student and later with grants from the Board of Agriculture and Fisheries. During this period she was engaged upon pioneer studies on nitrogen fixation by *Azotobacter* and on the growth-promoting substances ('auximones') of natural manures. Her published researches in this field led, in 1917, to the award of the D.Sc. (London). During 1917–22 she was successively demonstrator and University lecturer in botany at King's College and, continuing her researches, demonstrated the presence in natural manures of nucleic acid degradation products, including the purine bases, and examined their growth-promoting activities.

In 1922, Dr. Mockeridge was appointed independent lecturer in botany in charge of the Department of Biology of the newly established University College of Swansea. Here, in improvized accommodation and with a very small staff, she built up, over a period of thirty-two years, the reputation of the honours degree in botany and directed the work of a succession of research students. Her outstanding ability as a teacher and her scientific achievements in the face of inadequate facilities and often indifferent health were recognized by her election in 1936 as the first professor of botany in the College. She long pressed for the establishment of separate Departments of Botany and Zoology, and when, shortly before her retirement in 1954, this was to become possible by the decision to erect a new Natural Sciences Building (*Nature*, 179, 124; 1957) she planned the new facilities with great care and wisdom in full knowledge that their use would be for her successors.

Prof. Mockeridge also played a big part in the development of the University College, being dean of the faculty of science during 1933–35 and again during 1941–43, vice-principal during 1949–51 and, for many years, treasurer of the Student's Representative Council. She took a deep personal interest in the welfare and continuing progress of her students, whose affection and respect for her were recently expressed by their presentation to the Department of Botany of her portrait in oils.

She was always much sought after as a lecturer all over South Wales. For many years she was editor of the *Proceedings of the Swansea Field Naturalists' Society*. On her retirement she became chairman of the Science Committee of the National Museum of Wales and a member of the Glantawe Hospitals Management Committee.

H. E. Street

Sir Ralph Pearson, C.I.E.

Ralph Sneyd Pearson, who died on December 8, aged eighty-four, was educated at the Royal Indian Engineering College, Coopers Hill, and joined the Indian Forest Service in 1898.

After service as a territorial forest officer in the Bombay province, he was posted to the Forest Research Institute, Dehra Dun, to take charge of the recently formed Economic Branch in 1909. Until 1920 he had to work largely single-handed, devoting special attention to the adoption by the railways of antiseptically treated sleepers to relieve the heavy demands on the supply of naturally durable timbers. He also surveyed the possibility of using bamboo for paper-making on a commercial scale.

In 1920 the Economic Branch was much enlarged by the formation of several sections dealing with special aspects of the utilization of forest products, and Pearson was sent to Canada and the United States to recruit specialists to take charge of some of them. It was then that the results of the work he had done before and during the First World War began to gain the general acceptance they have since received with great benefit to Indian industry.

In 1925 he retired from the Indian Forest Service and returned to Britain, where he was appointed director of the new Forest Products Research Laboratory (Department of Scientific and Industrial Research), which he built up very much on the lines of his branch at Dehra Dun. There he remained until 1933, when he had to retire for reasons of health.

He was made C.I.E. in 1920 and was knighted in 1933; he received the honorary degree of LL.D. of the University of St. Andrews.

The author of several monographs on various forest products, his chief work was "The Commercial Timbers of India", written in collaboration with the late H. R. Brown, of the New York State College of Forestry. He was a good shot and a very keen cricketer who was always very popular with his staff.

He married Constance Ommaney, who died in 1938, and he is survived by two sons and a daughter.

W. A. Robertson

NEWS and VIEWS

Physical Biochemistry at Canberra : Prof. A. G. Ogston, F.R.S.

Dr. A. G. Ogston has been appointed to the chair of physical biochemistry in the Australian National University at Canberra. This is a new establishment, and his Department will be housed in the John Curtin Institute for Medical Research, where Prof. A. H. Ennor holds the chair of biochemistry. Dr. Ogston took a first-class degree in chemistry at Oxford in 1933. Later, in 1938, he took a degree in physiology and was appointed Oliver Gatty Fellow and Tutor in Biological Sciences at Balliol College. In addition to his college fellowship he holds the appointment of reader in biochemistry in the University of Oxford. His teaching and research have been characterized by an unusually clear understanding of both the physical and biological approaches and their relation to one another. His recent work has been concerned mainly with the properties of hyaluronic acid and its isolation from synovial fluid. Since 1955 he has been chairman of the editorial board of the *Biochemical Journal*. The formation of a department devoted to physical biochemistry in Canberra will be important, not only for the work it produces but also for the stimulus it provides ; the Australian National University is to be congratulated in attracting a scientist of such distinction. Dr. Ogston will take up the appointment in 1960.

Chemistry at Edinburgh : Prof. J. P. Kendall, F.R.S.

James Pickering Kendall, who is retiring from the chair of chemistry in the University of Edinburgh at the end of the present academic year, succeeded Sir James Walker in that chair in 1928, the appointment following an extensive experience of university teaching, research and administration as professor of chemistry in Columbia University, New York (1913–26), and in New York University (1926–28). His graduation in Edinburgh as M.A., B.Sc. in 1910 was followed by his association with Arrhenius and other continental workers in the earlier work on solutions, leading to his active research interest in general solution chemistry, with particular reference to ionic migration. The course of this work was accompanied by the publication of an extensive series of articles and text-books, particularly the Smith–Kendall series of college chemistries, and including "At Home among the Atoms" (1929), "Breathe Freely" (1938), "Young Chemists and Great Discoveries" (1939), and "Humphry Davy" (1954). He was elected a Fellow of the Royal Society in 1927.

During the past thirty years Prof. Kendall has taken a full share of Senatus and Faculty business—he is at present Dean of the Faculty of Science—and has served as a member of the University Court and of many of its committees. His tenure of the chair has been marked by many changes in the Department of Chemistry, particularly during the post-war period. These have included the institution of the Forbes chair of organic chemistry, to which Prof. E. L. Hirst was appointed in 1947, the enlargement and rebuilding of the Department and extensive developments in teaching and research. Prof. Kendall has for many years taken a great interest in the work of the Royal Society of Edinburgh, being in turn member of Council, secretary for meetings and general secretary, a post he occupied during 1939–49. During 1949–54 he served with distinction as president of the Society.

Dr. T. L. Cottrell

Dr. Tom Leadbetter Cottrell, who has been appointed to succeed Prof. James Kendall, received his early education at George Watson's Boys' College, Edinburgh. After entering the University of Edinburgh, he specialized in chemistry and graduated B.Sc. in 1943 with first-class honours. He then took a post in the Research Department of the Explosives Division of Imperial Chemical Industries, Ltd., where he developed his interest in physical chemistry. In 1946 he was seconded for special work in the Physical Chemistry Laboratory of the University of Oxford. Shortly after his return to Ardeer he was appointed head of the Physical Chemistry Research Section of the Nobel Division of Imperial Chemical Industries, Ltd. His contributions to the solution of fundamental problems in physical chemistry, with particular reference to chemical kinetics, thermochemistry and intermolecular forces, were of such outstanding merit that he was awarded in 1952 the Meldola Medal of the Royal Institute of Chemistry. Two years later he published a book on "The Strengths of Chemical Bonds", the second edition of which was called for after an interval of only four years. In 1958 he was awarded the D.Sc. degree of the University of Edinburgh for his achievements in physical chemistry. After a wide experience of both fundamental and applied research work at Ardeer, Dr. Cottrell was transferred in 1958 to the directorate staff of Imperial Chemical Industries, Ltd., at its London headquarters, where he acted as personal assistant to Sir Ewart Smith, deputy chairman of the Company. In returning to Edinburgh at the age of thirty-five, Dr. Cottrell will become a professor in the department in which his father previously held the post of lecturer in technical chemistry.

Royal Astronomical Society Awards

The Royal Astronomical Society has recently made the following awards : the Gold Medal of the Society to Dr. R. A. Lyttleton, lecturer in mathematics in the University of Cambridge, for his outstanding contributions to many branches of theoretical astronomy, in particular to the problems of the stability of rotating fluid masses, of the constitution of the stars and stellar evolution, and of the origin and peculiarities of the solar system ; and the Eddington Medal to Dr. J. S. Hey, of the Royal Radar Establishment, Malvern, for his outstanding discoveries concerning radio emission from the active Sun, radio reflexions from meteors, and discrete sources of cosmic radio emission.

Gold Medals of the Institut Francais des Combustibles et de l'Energie

Gold medals, designed to recognize outstanding achievement in the field of utilization of fuel and power, were recently presented in Paris to six fuel technologists of international reputation. The medals were a new foundation of the Institut Français des

Combustibles et de l'Énergie, and the presentations were made by M. Ramonet, the then Minister of Industry and Commerce. The recipients were Dr. D. T. A. Townend, director-general of the British Coal Utilization Research Association; Prof. W. H. McAdams, Massachusetts Institute of Technology; M. G. Darrieus and Prof. G. Ribaud, members of the Academy of Sciences, Paris; Dr. F. Münzinger, German Federal Republic; and Signor F. Squassi, presidente della Sezione Latium dell'Associazione Termotecnica Italiana.

A Large Sunspot Group

The large sunspot group which has recently attracted some attention appeared around the Sun's limb in heliographic latitude 12° N. on January 4. It was carried across the disk by the Sun's rotation about its own axis, and disappears at the western limb on January 17. A close bipolar structure, the group has somewhat diminished in area since January 8, when its area was 3,000 millionths of the Sun's visible hemisphere. It is, however, the largest group observed since May 1951 and, consequently, of the present sunspot cycle. Although there has been an unprecedented number of spots during the recent peak activity, no group has been observed approaching in size that seen in April 1947, the maximum area of which reached 6,100 millionths of the Sun's visible hemisphere and was the largest recorded since the Greenwich observations began in 1874. Adverse weather conditions at Herstmonceux have prevented continuous watch on this group, but so far (until January 11) no associated flare activity has been observed.

Central Advisory Water Committee

The Central Advisory Water Committee recently held its fourth meeting in London at the Ministry of Housing and Local Government, under the chairmanship of the Minister, Mr. Henry Brooke, when it received and adopted reports from two sub-committees set up in 1955 to inquire, respectively, into the growing demand for water and into the collection of information about water resources. Both reports will be published shortly.

The Committee requested the sub-committee on the demand for water to undertake a further inquiry, with extended terms of reference as follows: "In connexion with their investigations into the extent to which demands for water are increasing and the problems involved in meeting those demands, to inquire into the extent of uncontrolled abstractions of surface water for agriculture, especially irrigation, for industry and for other purposes, and into the effect of such abstractions on the quantity and quality of surface water available for all purposes; to consider whether powers are needed to control such abstractions in general or in particular; and to make recommendations". Prof. J. Proudman was appointed chairman of the sub-committee in succession to Alderman Yates, who has resigned from the chairmanship owing to pressure of other work.

Zoological Society of London: Young Zoologists Club

Although the Zoological Society of London has been in existence for more than a hundred years, it has never had a junior section through which the great amount of scientific knowledge at its disposal could be made available to school-children. About a year ago it instituted, with the co-operation of the educational authorities of the Greater London area, regular lecture-demonstrations for school-children. The Society is now launching a Young Zoologists Club (XYZ Club) for children between the ages of eleven and eighteen. The Club will be based on the London Zoo. For 10*s*. a year (there are, as well, reduced subscription rates for schools, clubs and natural history societies) the membership includes the Club badge, free admission tickets (to the London Zoo, including the Aquarium and Children's Zoo, and Whipsnade Park), competitions with substantial cash prizes, meetings, an Information Bureau and, above all, the *Zoo Magazine*, which for the present is being published three times a year. Further information can be obtained from XYZ Club, The London Zoo, Regent's Park, London, N.W.1.

Geochemistry

As a means of making available to all interested individuals some of the current Russian research in geochemistry, the Geochemical Society of the United States has undertaken to publish an English translation of the Russian journal *Geokhimiya*, published by the Academy of Sciences of the U.S.S.R. The first number of this translation has now appeared (*Geochemistry*, No. 1, 1958. (A translation of the journal of the Academy of Sciences, U.S.S.R.) Pp. 1–130. Subscription (for eight issues) 20 dollars a year. Ann Arbor, Michigan: Geochemical Society, Prof. E. Wm. Heinrich, Mineralogical Laboratory, The University, 1958). It contains research papers dealing with the ionium method of determining the age of marine sediments, the formation of free hydrogen in the Earth's crust, X-ray investigations of natural oxides of uranium, paragenesis in boron-bearing magnesium skarns, the evolution of rocks during progressive metamorphism, the distribution of cobalt, nickel and copper in hydrothermally altered rocks, experimental studies of the oxidation of cobalt and nickel arsenides in solutions containing oxygen and carbonic acid, rhenium in molybdenites, the zirconium/hafnium ratio in zircons, and a contribution to the geochemistry of titanium in intrusive processes of granitic series. The translation concludes with a brief description of the recent International Conference on Interplanetary Science.

Symposium on Peptide Synthesis

An International Symposium was held in Prague during September 8–15, when chemists from many countries in Europe met, at the invitation of the Czechoslovak Academy of Science, to discuss the synthesis of peptides. The primary object of the symposium was to exchange experience in this field rather than to communicate new work (although several of the contributions included unpublished work), and as a basis for each section of the discussion reviews were contributed by Prof. T. Wieland (Frankfurt) on peptide bond formation based on carboxyl activation; Prof. S. Goldschmidt (Technische Hochschule, Munich) on peptide bond formation based on amino-group activation; Dr. G. T. Young (Oxford) on racemization in peptide synthesis; Dr. E. Wünsch (Max Planck Institut, Munich) on amino-group protection; Prof. E. Taschner (Danzig) on carboxyl group protection; Dr. J. Rudinger (Prague) on peptides of the diamino and dicarboxylic acids; Prof. M. Brenner (Basle) on peptides of the hydroxy-amino-acids; Dr. Young on peptides containing cysteine; Prof. M. M. Shemyakin (Moscow) on

peptides of α-substituted α-amino-acids; and Dr. M. Rothe (Berlin) on the synthesis of cyclic peptides. A paper on the synthesis of optically active peptides from racemic amino-esters, by Prof. M. M. Botvinik (Moscow), was read in her absence. The proceedings, with the discussion, are to be published in a special issue of the *Collection of Czechoslovak Chemical Communications*. It was generally agreed that the meeting had been most rewarding, and that an attempt should be made to gather regularly in this fashion.

World Low Air Temperature Record

THE world low air temperature record of − 102·1° F. at the South Pole on September 18, 1957 (*Nature*, 181, 1109; 1958), was exceeded in the polar night of 1958 at the Russian International Geophysical Year Antarctic stations Sovetskaya (78° 24′ S., 87° 35′ E., elevation about 3,700 m.) and Vostok (78° 27′ S., 106° 52′ E., about 3,500 m.) The Sovetskaya station recorded − 86·7° C. (− 124·1° F.) between 1900 and 2000 L.M.T. on August 9. The measurement was made with a distant-reading electrical-resistance thermometer of known correction. The temperature is stated to have been lower immediately afterwards but there was no calibration for the thermometer. Other readings nearly as low at these stations were:

Vostok:	− 80·7° C.	(− 113·3° F.) on June 15
	− 85·8° C.	(− 122·4° F.) on August 8
Sovetskaya:	− 81° C.	(− 113·8° F.) on June 19
	− 83° C.	(− 117·4° F.) on June 25

The extremes in June occurred in periods of light winds and clear or nearly clear sky, which is the weather most favourable for very low temperatures. No information is available about the weather at the time of the August readings. The values were stated in reports from the American meteorologist, Mr. Morton Rubin, at the Russian base at Mirny, published in the *Monthly Weather Review* of the U.S. Weather Bureau.

Oystercatchers and Mussels

R. E. DRINNAN, of the Fisheries Research Board of Canada and formerly of the Fisheries Experiment Station, Conway, has described the feeding of the oystercatcher (*Haematopus ostralegus*) on the edible mussel (*Mytilus edulis*) in the estuary of the River Conway, Caernarvonshire, during the winter 1955–56 (Ministry of Agriculture, Fisheries and Food Fishery Investigation, Ser. 2, 22, No. 4). Feeding was studied on the mussel beds at the mouth of the River (Morfa) and in an area higher up the estuary above the suspension bridge (Pensarn). The oystercatcher populations of these areas are discrete. The birds are present between August and late March and are probably British breeding birds. Feeding follows the tidal cycle, continuing throughout the period when mussels are uncovered, high water periods being spent in non-feeding roosting flocks. This cycle continues during darkness. Quantitative data on food intake for the daylight feeding period show that each bird eats about its own weight of wet mussels a day. No precise measure of the effect of oystercatcher predation on the mussel population was made; but, at the Morfa, population samples through the winter showed the steady removal of the larger size groups by the birds. The present work is compared with previous results obtained by Dewar in the Firth of Forth and many divergences noted. These can all be ascribed to differences in feeding behaviour of the birds in the two studies.

Harwell Reactor School Courses

A SECOND course on the Control and Instrumentation of Reactors will be given at the Harwell Reactor School, Berkshire, during July 7–17, and will be open to British and overseas students. The topics to be treated will include: revision of elementary reactor kinetics, control and instrumentation; automatic control of reactors and nuclear power plants; application of computers; reactor transfer functions and function analysers; neutron flux scanning; radiation detectors and their siting in reactors; reactor safety circuits; conventional instrumentation; use of transistors in reactor instrumentation; burst slug detection; spatial instabilities in reactors; and data-reduction problems on large reactors. In addition to the lectures, there will be visits to zero-energy and high-flux research reactors and other relevant parts of the Atomic Energy Research Establishment. The fee for the course will be 50 guineas, exclusive of accommodation, and application forms, available from the Reactor School, must be returned by May 7 to the Principal.

United States Atomic Energy Commission Training Courses

THE U.S. Atomic Energy Commission has established a training programme at the Shippingport Atomic Power Station for supervisory personnel of domestic and foreign organizations engaged in or planning the design, construction or operation of nuclear power plants. The training programme is being conducted at the Shippingport Atomic Power Station, Pa., a joint project of the Commission and the Duquesne Light Co., because it is the only large-scale nuclear electric power plant at present in operation in the United States. It will be conducted by the Duquesne Light Co. for the Commission, and will enrol twenty-five participants every three months for a six-month training course, which will include lectures and practical plant work. The courses, the first of which started on January 5, are designed to acquaint the participants with the operation of the Shippingport plant and to provide operational training within the plant. The tuition charge is 2,000 dollars to cover associated operating costs.

University News: Birmingham

THE Council of the University of Birmingham has received from the firm of Joseph Lucas, Ltd., a gift of £100,000, to be used for building a hall of residence for graduate students in engineering.

The title of reader in experimental pathology has been conferred on Dr. K. W. Walton, senior lecturer in experimental pathology, and that of reader in mathematical economics on Dr. F. H. Hahn, senior lecturer in economics. The following appointments have also been made: Dr. D. B. Idle, to be lecturer in botany; Dr. B. John, to be lecturer in cytology in the Department of Genetics; Dr. R. G. O. Kekwick, to be lecturer in malting and brewing and applied biochemistry.

Leeds

MR. J. TRENAMAN has been appointed to the Granada Television Research Fellowship, endowed by Granada TV Network, Ltd., in the University of Leeds, for a minimum period of five years, with provision for the necessary staff and services. The purpose of the Fellowship is to undertake research

into the impact of television over as wide an area of inquiry as practicable in the fields of entertainment, politics, information and public affairs—and into its influence on public tastes, habits and outlook. Mr. Trenaman read English at King's College, London, and later graduated B.Litt. in the University of Oxford. In 1945 he was appointed head of analysis in the B.B.C. Audience Research Department, and in 1948 became research officer to the B.B.C. Further Education Experiment exploring the use of broadcasting as a medium of education. He has since held the post of further education liaison officer to the B.B.C.

"Fuel and Power in British Industry"

Mr. A. M. Wandless, of the Scientific Department, National Coal Board, writes: "In the article under this title which appeared in *Nature* of December 20, I am reported as having stated in my address to the Manchester Joint Research Council's Symposium on Fuel and Power that the workable reserves of coal in Britain are of the order of 1,000 million tons. This, of course, is an absurdly low figure. In dealing with the difficult and necessarily uncertain business of attempting to predict workable or economic reserves of coal, I said that figures as low as 44,000 million tons (that is, 200 years life at the present rate of extraction) had been computed, but that this estimate was almost certainly too low. I suggested an upper ceiling of 100,000 million tons, but I pointed out that it all depends how much we are going to need coal in the future, and what we are prepared to pay for it. There is probably something of the order of 170,000 million tons lying in the ground in seams more than 1 ft. in thickness".

Birds and Mammals of Canada

Reference was made in *Nature* of November 15, p. 1347, to two recent publications from the National Museum of Canada, namely, "Quelques Oiseaux du Canada" and "Canadian Mammals". We are informed that the first of these is available also in English under the title "Some Canadian Birds", this being the original version. The price is the same as that of the French edition, 35 cents.

Announcements

An honorary degree of doctor of technical science was conferred on Sir John Cockcroft by the Technical University of Delft on January 10.

Prof. J. M. Yoffey, professor of anatomy in the University of Bristol, has been appointed Knight first class of the Order of the Dannebrog for his services to the Medical Schools of the Universities of Copenhagen and Aarhus.

Mr. Gustavus Green, known for his work on the design and development of the early Green aero-engines, has been made an honorary companion of the Royal Aeronautical Society; Mr. Green was born in 1865 and designed the 60-h.p. engine used in a Short No. 2 biplane flown in 1909.

Sir Russell Brain, president during 1950–57 of the Royal College of Physicians, will give the Eddington Memorial Lecture for 1959 in Cambridge, at the Arts School Lecture Theatre, Bene't Street, on February 24, at 5 p.m. The title of the lecture will be "Science, Philosophy and Religion".

The Czechoslovakian Academy of Sciences and the Purkyne Medical Society have arranged a symposium on antibiotics, to be held in Prague during May 18–23. The symposium will be divided into three sections on: problems of the biosynthesis of antibiotics; the scientific pathophysiological basis of antibiotic therapy; and the problems of fermentation engineering and the non-medical uses of antibiotics. Summaries of papers covering new and unpublished results, to be read in English, German, Russian or Czech, should be received by the secretary, Dr. M. Hermansky, Antibiotics Research Institute, Rostoky, near Prague, not later than February 15.

The third conference on Electronic Digital Computers and their Industrial Applications will be held in the Department of Mathematics, College of Technology, Birmingham, on February 25, when members of the English Electric Co. will deliver talks on the installation, operation and maintenance of digital computers; programming strategy and techniques, including automatic programming; engineering and scientific problems; the use of a computer system in commercial organization; and the mortgage problem. Applications can be made to the Registrar, College of Technology, Gosta Green, Birmingham 4.

An international symposium under the auspices of the Centro per la Vaccinazione Antitubercolare of the Istituto d'Igiene dell'Universita di Pisa, devoted to the topic of vaccination against tuberculosis with non-living vaccines, will be held in Florence during April 5–7. The organization of the meeting has been undertaken by the director of the Centre, Prof. Giulio Buonomini, from whom further information can be obtained. The symposium is intended to provide an opportunity for the exchange of information, experiences and ideas by investigators actively engaged in attempts to produce a safe and effective non-living vaccine against tuberculosis. To assure a maximum degree of informality and freedom of discussion, participation in the symposium has been limited to about twenty invited workers.

The National Academy of Sciences with the joint sponsorship of the National Science Foundation, the Office of Naval Research and the Air Force Office of Scientific Research has arranged an international seminar on "The Atomic Mechanisms of Fracture", to be held at the New Ocean House, Swampscott, Massachusetts, during April 12–14. The central theme of the conference is the basic atomic mechanism by which fracture occurs in metals, ceramics and polymers; emphasis is placed on fundamental studies of the basic mechanisms of cleavage and of ductile, fatigue and high-temperature fractures. The programme will consist of a series of invited papers, which will be circulated in advance. Further information and forms of application can be obtained from Prof. B. L. Averbach, chairman, or Dr. D. K. Felbeck, secretary, Conference on Fracture, National Academy of Sciences, 2101 Constitution Avenue, Washington 25, D.C.

Mr. W. A. Ferguson, who has been appointed secretary of the British Museum (Natural History), is at present in the Director's office, British Museum (Bloomsbury), and not at South Kensington, as stated in *Nature* of January 3, p. 18.

SCIENTIFIC RESEARCH IN AUSTRALIA

THE ninth annual report of the Commonwealth of Australia Scientific and Industrial Research Organization* covers the year 1956–57, in which expenditure was £6,575,255. Of this, £935,830 was expended on investigations financed from the Wool Research Trust Account, which under the new Wool Research Act should now have an income of about £1,700,000. Some new arrangements were made with the universities, including the establishment with the New England University, Armidale, of a laboratory to be used jointly by the University's Faculty of Rural Science and the Organization's Regional Pastoral Laboratory, Armidale; and, with the University of Melbourne, of a joint Engineering Research Station for the study of soil mechanics. Two main research projects relating to water supplies have developed with great promise. The Division of Radiophysics full-scale field trial of artificial rain-making over the Snowy Mountains over two winters promises an increase in rainfall over the target area, and the Mansfield process using cetyl alcohol, developed in the Division of Industrial Chemistry, is now finding application in reducing evaporation from small farm dams and, in modified form, is effective in large reservoirs.

Special reference is made to the completion by the Cattle Tick Research Review Committee of its survey of research within its field. The Committee recommended completion of the ecological background and field tests of pasturing and strategic dipping; studies of tick fevers to assess the consequences of efficient control of ticks; toxicological investigations, especially completion of the work on DDT; and the study of resistance to tick in cattle. The investigations to establish the genetic factors which enable cattle to withstand tropical conditions have indicated that the rate of sweating of zebu cross-breds is not necessarily higher than the average of British breeds, and their ability to withstand heat is thus related to other factors.

In soils research special effort has been directed to the preparation of a new soils map of Australia, and it is hoped to complete the whole project by 1960. In soil chemistry a start has been made on the study of the geochemistry of the three main groups of soils developed on dolerite in Tasmania. In soil physics an equation has been derived for the relation between permeability and the size-distribution of the pores in isotropic porous material, and recently the Division has included soil-stabilization projects in its programme.

The development of the Tobacco Research Institute at Marceba has progressed and work commenced on tobacco culture, while at Canberra blue-mould disease is being investigated. The investigations into the possibility of establishing safflower as an oil crop in Australia have been concluded. Varieties giving economic yields of oil of high quality have been developed, and the returns per acre were equal to those from wheat in areas suited to the crop. Broad-scale ecological surveys were carried out in the under-developed arid and semi-arid regions of the continent to assess their potential land-use and to investigate problems of agricultural and pastoral development. In work with skeleton weed in cereal crops, selective weed-killers applied before sowing wheat or in the early seedling stage of oats have given marked increases in the yield of grain, due to an increase in the nitrogen available to the crop, while improvement programmes with cattle pastures have enabled cattle in the spear grass region to be marketed one year earlier than is possible from native pastures; in the coastal lowlands sheep and cattle can now be wholly maintained on sown pastures; and in the brigalow country introduced grass and legume species have given highly promising results. Indolyl-3-acetic acid increased the growth of both the veins and petioles of leaves according to a similar pattern, and work has commenced on the recognition of factors which may control leaf-blade (laminar) growth. A study has been made of the ultra-violet spectra and acid-strength of some chlorinated phenoxyacetic acids and their phosphonous and phosphonic acid analogues. Reconnaissance of the east Australian rain-forests was complete, while work in the Murrumbidgee Irrigation Area indicated that impedance to the flow of water in farm ditches due to inflorescences of *Paspalum dilatatum* can be removed by spraying with maleic hydrazide.

Biophysical research supported at the University of Tasmania includes the development of microelectrode techniques to measure potential differences between points in the cytoplasm of large plant cells such as *Nitella* and *Chara*, further studies of the steady electric field pattern around plant roots growing in solutions of various ionic compositions and concentrations, and studies of the nature of transient changes in the electric field of bean roots following stimulation.

The Plant Fibre Section is developing methods of chemical analysis for examining the changes associated with the conservation and storage of fodder both as hay and silage, and the research programme of the Division of Animal Health and Husbandry continued to place emphasis on contagious pleuropneumonia of cattle, infectious forms of infertility and worm parasites, besides the tick research already noted. Good progress is reported with the major production problems with cattle, but—with the greatly reduced significance of the sheep blowfly and other external parasites of sheep through increased knowledge of diseases of sheep and the advent of modern insecticides—research on sheep has been greatly reduced. Nevertheless, foot rot and foot abscess, mycotic dermatitis and worm parasites continue to occupy an important place in the Division's research programme.

Insect ecology and physiology have continued to be the two principal research themes of the Division of Entomology, but besides the developing emphasis on cattle-tick research, the biological control of weeds and the Queensland fruit-fly are increasingly important. Work on the biological control of Noogoora burr was initiated, and the nature of insect resistance to insecticides was further studied

*Commonwealth of Australia. Ninth Annual Report of the Commonwealth Scientific and Industrial Research Organization for the year 1956–57. Pp. 179. (Canberra: Government Printer, 1958.) 10s. 6d.

in several strains of house-fly. The Wildlife Survey Section concluded its investigations of the marsupials of New South Wales and continued its work on rabbit myxomatosis, while the Division of Fisheries and Oceanography is investigating the interaction between sunlight and chlorophyll in marine plants to enable carbon dioxide in the water to be converted into plant and animal tissue. The Division of Food Preservation and Transport continued to investigate the reaction products in browned freeze-dried apricots and peaches and completed the identification of the cationic constituents, and in a series of studies parallel with those on the 'tenderizing' of beef examined the breakdown of nucleotides in the muscle tissue. Much effort was made to improve methods for killing fruit-fly in harvested fruits, and studies designed to determine the effect of different amounts of initial oxygen in the head space of highly corrosive canned products were continued with test packs of blackcurrants in syrup.

An extensive programme of research has been undertaken to improve the use of wool as a textile fibre, using increased knowledge and understanding of the complex structure of the wool fibre and its physical and chemical properties to improve it as a textile fibre. Much attention has been directed to simplifying the conventional techniques of worsted processing, and investigations continued on the treatment of woven fabrics with casein, with the object of devising an inexpensive method of shrink-proofing using aqueous solutions. Besides studies on the extension of wool fibres and their setting at new lengths, either temporarily or permanently, research on the degradation of cellulose by fungal enzymes has been diverted from the problem of protecting tent canvas against attack by moulds and linked with research on the digestibility of pasture plants by sheep. The study of the constituents of wool-wax is now concerned chiefly with the long-chain acids of the wax and with lanosterol.

Besides the Mansfield process already noted, an outstanding success of the work of the Division of Industrial Chemistry has been the zirconium–hafnium separation process resulting from its study of the chemistry of Australia's beach sands. Work on the industrial extraction of germanium from the flue dusts of coal-burning power stations continued. Crystallographic studies were directed to the chalcogenide systems of thorium with sulphur, selenium and tellurium. A novel method was evolved of increasing the resistance of concrete products to attack by sulphate solutions. Work was commenced on some aspects of fighting bush fires, the nucleation of clouds, and the separation of the components of tar from the Lurgi process for gasifying brown coal. The theoretical and experimental study of defects in crystals and of their implications in determining the physical and chemical properties of solids continued, as well as the search for alkaloids of possible pharmaceutical value from the native flora, a study of root exudates and their possible significance to agriculture, and the examination of plants known or suspected to be poisonous to live-stock. Considerable progress is reported in basic studies of the chemical reactions of importance in the pressure gasification of brown coal.

The Division of Tribophysics reports major advances in the knowledge of distortions in metals produced by plastic deformation and of topology and reactivity of metal surfaces, and it appears that grain-size is important in controlling both the plastic properties of copper and its annealing characteristics. Demands on the services of the Division of Metrology are increasing, and the electrolytic condensation hygrometer developed by the Division of Physics has fulfilled its early promise, and studies of the basic physics of the crystal surface were made. Research work at very low temperatures was extended to include studies of paramagnetic resonance, and work is in progress to determine the gyromagnetic ratio of the proton. In dielectrics research the emphasis was chiefly on the effect of crystal imperfections on the dielectric properties of solids, but some work continued on liquids, and a theoretical investigation was made of problems related to superconductivity in metals.

The Division of Radiophysics is investigating the basic physical properties of semiconducting materials, and the Organization is undertaking basic studies of the physics of the atmosphere with the view of obtaining a more fundamental knowledge of the weather and the processes which control it. These include further intensive field work in the 'cool change' project, in addition to the Snowy Mountains project already noted, and towards the end of June 1957 emergency operations were commenced in an attempt to induce the maximum possible precipitation from any suitable cloud formations over general areas of the eastern States where drought conditions were beginning to be experienced. In radio astronomy, two large Mills cross-aerials were completed for the study of radio waves from beyond the solar system, and a long programme of observations of the southern part of the Milky Way at a wave-length of 21 cm. yielded interesting results on the general structure of the Galaxy. A new crossed-grating interferometer, designed for high-resolution observations of the Sun, was completed and is in operation. Lists of staff and personnel of the council and committees of the Organization and of published papers are included in the report.

FINANCE OF SCIENTIFIC RESEARCH IN BRITAIN

IN opening an adjournment debate in the House of Commons on December 18 on Government aid to science in Britain, Mr. F. Willey urged the need for more wholehearted support for fundamental research and a bolder approach to science such as characterizes the National Science Foundation in the United States. He suggested that the main responsibility for fundamental research must rest with the Government, but that much other scientific research requires Government assistance in some form and that industry must be persuaded to devote more resources to research. Referring more particularly to the Department of Scientific and Industrial Research, he suggested that the appointment of a full-time chairman to the Council should be considered, and that the status and authority of the Department should be increased. Mr. Willey was disturbed about the disbandment of the Microbiological Group at the National Chemical Laboratory. Nevertheless, he paid a tribute to the work of the present Lord President of the Council,

which was endorsed by Mr. R. Fort, who, while in general supporting Mr. Willey's views, argued that fundamental research should properly be the responsibility of the universities. Like Mr. Willey, he echoed some criticism of the British national organization of research which has been recently voiced in *Nature*, but thought that the four research councils provided a good mechanism for determining research priorities and that this pattern could be more widely applied.

In his reply for the Government, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, after reviewing briefly the general pattern of Government support for civil science, pointed out that in the past two years the expenditure of the Department of Scientific and Industrial Research has increased by 23 per cent, of the Medical Research Council by 34 per cent, of the Agricultural Research Council by 20 per cent, and of the Nature Conservancy by 25 per cent. He then announced that the Government has decided to repeat the experiment of financing the Department of Scientific and Industrial Research on a five-year basis. In the first quinquennium ending on March 31, 1959, total expenditure would be about £36 million; for the next quinquennium a total of £61 million is envisaged, reaching £14 million for 1967–68, excluding the contribution to the European Organization for Nuclear Research. Paying tribute to the work of the research associations, Mr. Nicholls said that the thirty-nine research associations and ten smaller organizations in the scheme employ a staff of 4,500, of whom 1,500 are of graduate status, and the 20,000 member firms cover about 50 per cent of manufacturing industry. To their expenditure of about £7 million in 1957–58 the Department of Scientific and Industrial Research contributed about £1·75 million in grants, and for the next quinquennium this will be increased to more than £2 million.

In regard to the universities, Mr. Nicholls agreed that we should look to them mainly for fundamental research and he stressed the value of the increase of postgraduate awards by about 10 per cent in the next five years. By 1963–64, 3,800 students will be receiving grants for training and research from the Department of Scientific and Industrial Research compared with 1,900 this year, and the amount available for research in universities and similar institutions will also be increased three-fold or four-fold in the next five years. In the current year university building projects to the value of £12 million are being started; for the years 1960–63 this will rise to £15 million a year, and technical college building projects to the value of £15 million a year had been in hand since the end of 1956. He had every reason to believe that the target output of 20,000 scientists and engineers a year set for the late 1960's will be achieved.

In conclusion, Mr. Nicholls said that he understood the decision of the Council for Scientific and Industrial Research with regard to the Microbiological Group at the National Chemical Laboratory was taken entirely on scientific merits and without any Ministerial intervention, which would have been entirely contrary to the spirit of the Act. The Lord President was satisfied that the Council had given extremely careful thought to the matter before giving its decision. Mr. John Hynd later referred to the outstanding £130,000 in the capital cost of constructing the Jodrell Bank radio telescope. Mr. Nicholls, in reply, pointed out that the House itself had welcomed the assurance that no voted money should be spent on covering this outstanding item. Later, in a written answer, he added that the Department of Scientific and Industrial Research had already provided £350,000 towards the cost of construction, and had funds at its disposal for financing research of special timeliness and promise. Any applications from the University of Manchester for grants for future research involving the use of the radio telescope would be considered on their merits, and one such grant of £15,200 had recently been offered.

A RADAR SIMULATOR SYSTEM

DURING the Second World War the training of Royal Air Force radar operators was greatly facilitated by the use of apparatus which enabled aircraft echoes to be simulated on the screen of the cathode-ray oscillograph in the radar receiver. Much ingenuity was applied to devising techniques whereby such artificial echoes could be produced and applied to the radar in such a way as to simulate the movement of a real target. By the use of the training equipment which resulted, the need to produce real echoes by flying aircraft was obviated, with consequent savings in fuel, wear and tear of aircraft and elimination of the difficulties of organization and administration.

From these war-time beginnings subsequent development of radar trainers has been considerable, as was shown by the demonstration recently given at the Farnborough works of Solartron Electronic Group, Ltd., of an elaborate installation for simulating air defence exercises and providing realistic instruction in the radar control of the interception of bomber aircraft by fighters. The equipment has been developed under the auspices of the North Atlantic Treaty Organization for use by the Italian Army.

The installation includes seven desk consoles each containing circuits for generating pulses which, when applied to the display oscillograph of a radar receiver, appear as normal aircraft echoes. Each console can simulate two aircraft. Means are provided in the consoles for moving an 'aircraft' along any desired track at speeds which may be varied between its stalling and maximum speeds. Controls are also provided for rate of turn and rate of climb, again in accordance with the capabilities of the aircraft being simulated.

All 'echoes' are displayed on a central plan position indicator from which the general state of the exercise may be studied.

The echo signals, which may be designated as originating from friendly or enemy aircraft as desired, are also displayed on the plan position indicators of a radar receiver. In so doing, the apparatus takes into account the horizontal and vertical radiation patterns, including side lobes, of the aerials of the radar being simulated. These plan position displays enable interception techniques to be practised by a controller who telephones instructions to the operator of the desk console simulating the fighter, who varies

the course of the fighters so as to bring about interception of the bombers. Bomber control may be carried out if required by a controller at another plan position indicator.

An interesting adjunct to the equipment is the simulation of electronic radar counter-measures both by parachuted noise jammers and by the dropping of strips of metal foil ('window'). In both cases means are provided in the equipment to take into account the effect of the prevailing wind on the drift of the jammers.

In the design of this versatile installation, the likelihood of future changes in the performance of aircraft and radar, and of air defence procedure in general, have been borne in mind, and the necessary modifications and additions to the installation to deal with such changes are readily made.

Equipment similar in principle to that demonstrated may be used for simulating marine exercises in which both radar and asdic are used, and it may also be used for training in civil air-traffic controls.

A. F. Wilkins

CHEMISTRY AND QUANTUM CHEMISTRY

In the course of the past twenty-five years the language of quantum mechanics has invaded almost every branch of chemistry. Often this has been at a very qualitative level involving only such basic concepts as those of stationary states and energy-levels. Many of the most useful ideas, however, are ones which do not belong to accurate quantum mechanics but arose first in certain approximate calculations and have since been developed by using them to explain experimental facts. These range from the idea of a crystal potential which is used to make qualitative predictions about molecular complexes, to ideas such as hybridization and resonance which are used qualitatively to describe the structure and reactivities of molecules. Unfortunately, it is becoming very clear that most of these ideas need careful re-examination both to establish their quantum mechanical status and to show how they can be refined or modified to explain the more extensive and more accurate experimental results now available.

It was very appropriate, therefore, that this problem of the correspondence between the concepts of chemistry and those of quantum chemistry should have been the subject of a panel meeting held at Vålådalen, in the Swedish mountains, during August 26–30 and organized by Dr. P. O. Löwdin, director of the Quantum Chemistry Group in Uppsala. The audience consisted primarily of experimentalists who had spent the previous month there at the summer school on quantum chemistry, and the panel included both chemists and quantum chemists. The meetings were pleasantly informal, and, since the number of prepared contributions was deliberately kept small, there was ample time to discuss fundamental problems.

The theory of molecular structure based on the overlapping of hybrid atomic orbitals which are concentrated in the bond directions was one topic discussed, and in particular the idea of assigning a constant atomic radius to each kind of hybrid. Experimental methods of determining molecular structure using micro-waves, electron diffraction and X-rays were reviewed by Prof. B. Bak (Copenhagen), Prof. K. Hedberg (Oregon), Prof. O. Bastiansen (Trondheim) and Dr. I. Lindqvist (Uppsala), and they reported that the accuracy and flexibility of these methods had recently increased considerably. The results were shown by Prof. Bak and Dr. I. Hjalmars (Stockholm) to imply that the approximation of a constant radius for each hybrid is often accurate to 0·001 A. Furthermore, as Prof. L. Pauling (Pasadena) showed, the rotational barriers can be predicted by including in the hybrids small amounts of higher angular terms, and the experimental confirmation of these predictions was discussed by Prof. L. Pierce (Notre Dame). On the other hand, Dr. Löwdin pointed out that the principle of maximum overlapping is quantitatively inaccurate even on an approximate theory and that the accurate theory does not even give any unique hybrids. In consequence, it is difficult to believe that the hybrids have any physical reality. Prof. R. S. Mulliken (Chicago) agreed that there is still no basic theoretical reason why covalent radii should be so constant.

There was general agreement on the artificial nature of the distinction often made between ionic and covalent binding. Both Dr. S. Lundqvist (Uppsala) and Prof. H. Shull (Indiana) pointed out that ionic wave-functions can sometimes give covalent properties and be almost identical with corresponding covalent wave-functions. This led naturally to a discussion of the method of 'atoms in molecules' which uses such wave-functions. Dr. R. Pauncz (Haifa) showed that, when the method is applied literally to hydrogen, the results are rather poor, but Dr. H. Preuss (Göttingen) defended the method in a modified form. It seems clear that the unmodified free atoms or ions do not provide the best units for describing the compound.

The concept of hyperconjugation is also in some difficulties. This type of delocalization of the electrons plays an important part in the excited states and ionized states of many molecules and in transition complexes, but it is not so clear that it is important in molecular ground-states. The concept was strongly defended by Prof. Mulliken, and he claimed that there is sufficient experimental evidence to substantiate it even for the ground-state. The concept of conjugation also has recently been attacked, but Prof. Mulliken thought this was because the simple Hückel theory sometimes exaggerated its effects, for example, in butadiene, whereas more recent theories give much better agreement with experiment. Dr. R. McWeeny (Keele) argued that the study of diamagnetic susceptibility and proton magnetic resonance gives very strong evidence for conjugation, although Prof. Bak and Mr. R. A. Hoffman (Uppsala) pointed out that some proton magnetic resonance effects in conjugated molecules are not yet understood. Dr. S. Sunner (Lund) talked about difficulties in understanding resonance and strain energies and suggested that these are often due to the use of unrelated or inappropriate reference states.

A point which emerged clearly from the discussion is the growing tension between the so-called semi-

empirical methods and those based on *a priori* calculations. Mr. C. Schäffer (Copenhagen), for example, described the successful use of crystal-field theory in explaining the spectra and properties of molecular complexes. Yet, as Dr. Löwdin insisted, the model does break down when refined too far and the empirical values of the parameters do not agree with those calculated. The resonance theory is another example of a theory which is still useful qualitatively and semi-quantitatively despite the fact that some of its assumptions are in serious error. The success of the simple Hückel theory, according to Dr. G. G. Hall (London), is not due to the accuracy of its assumptions but to the mathematical resemblance between its equations and those of a more accurate theory, and it may be that such resemblances occur for other theories.

The urgent need for more accurate theories and concepts appropriate to them was felt several times during the meeting. Dr. H. G. Bennewitz and Dr. G. Gräff (Bonn) underlined it by describing molecular-beam experiments which yield very accurate values of many molecular constants. Prof. F. A. Matsen (Texas) and Dr. Hall favoured the method of different orbitals for different spins as a method more accurate than that of molecular orbitals yet as easy to visualize. There was also a vigorous discussion on the rival merits of natural orbitals and population analysis as methods of understanding complicated wave-functions.

A discussion of the future of quantum chemistry provoked some differences of opinion. In the view of Prof. Mulliken, the calculation of good molecular orbital wave-functions, which is now beginning, will help greatly to clarify molecular structure and will enable generalizations about correlation energies to be made. Dr. Löwdin thought that the effects of correlation and relativistic corrections will be of importance in many chemical problems and should be investigated using more accurate wave-functions. On the other hand, Dr. Hall believed that *a priori* calculations will never be possible for more than a small number of molecules and that it is just as important to study accurately the relations between the molecules of a molecular series. Prof. Matsen considered that the experimentalists' need for concepts with which to organize and understand their results is so urgent that they may be forced to invent these without waiting for the development of quantum mechanical ones. It was Prof. Pauling's hope that the present introspective phase of quantum chemistry, though obviously necessary, will not last very long, since there are many urgent chemical problems which could be solved more easily theoretically than experimentally.

G. G. Hall

NATURAL SELECTION IN MAN

In a year marked by the celebration of the Darwinian–Wallace centenary, it is fitting that a symposium, sponsored by the Society for the Study of Human Biology and held on November 8 in the Department of Anatomy, University College, London, should have focused attention on modern analyses of the action of natural selection in human populations. The symposium comprised six papers, and in five of these attention was directed to a greater or lesser extent towards genetical matters, knowledge of which is basic to studies of the promotion of evolutionary change by selective forces. In the final contribution, the field was still further expanded by the consideration of a number of broader questions connected with primate (including human) evolution.

The balance of the whole symposium was such as to indicate clearly the extent to which, despite much intensive work, knowledge of many aspects of human inheritance and selection theory still falls short of that now available for some other animal species. Little is known, for example, of the multifactorial control of quantitative human features; but, on the other hand, a considerable body of information has accumulated in relation to certain groups of major human genes, and several speakers addressed themselves to problems associated with the action of selection upon individuals distinguished by the possession of easily identifiable allelomorphs.

Two of several problems basic to present-day studies of natural selection in man are, as pointed out by Prof. L. S. Penrose (University College, London) in an opening paper, the recognition of these major genetic factors and the determination of the frequencies at which they exist in different populations. The first of these aims has, in many cases, now been attained by analyses of the human pedigrees to the compilation of which much early work was directed. The second has only been achieved on any considerable scale in the case of such factors as those which determine the blood groups, but in this particular case, data are now available from widely scattered regions of the world.

Genetic factors of this type must, as pointed out in the opening paper, have arisen at some time by mutation, but such origins of new variability are rarely recorded. Thus, despite the thoroughness with which the blood-group systems have been studied, mutation in them has not been observed. Indirect evidence, however, indicates its occurrence, sometimes at relatively high rates. Achondroplasia, for example, results from the effect of a single dominant major gene which has in certain populations remained in circulation for long periods. The condition is associated with a marked degree of infertility, and the genetic wastage which thereby results must presumably be made good continually by new mutation.

Recessive genes which, when substituted in double dose into certain genetic complexes, may exert markedly deleterious effects on viability exist in heterozygous form in all populations. They provide a source of potential variability which if liberated would, even in the absence of mutation, form an adequate basis for considerable amounts of evolutionary change. The scope and selective significance of this potential variability are difficult to assess from the available human data, but a reminder of their extent was given by Prof. Th. Dobzhansky, who, as the guest speaker, presented in outline the results of his own extensive work on the hidden genetic variability in wild populations of *Drosophila*.

The selective significance of each factor may be suggested by studies of the effects which it exerts on the processes of growth and development. This aspect of human genetics is still little explored, but a measure of the selective significance of any factor is given by the reproductive 'fitness' which it confers upon the individual. The estimation of fitness presents a number of technical difficulties, which were outlined in a paper by Dr. C. A. Clarke (University of Liverpool). Basically, the problem involves an assessment of the numbers of offspring which reach reproductive age, produced by individuals carrying the mutant allelomorph, relative to those produced by remaining members of the population. The value so obtained measures fitness in only a single selective environment, and, apart from the difficulties associated with the identification of individuals carrying recessive mutants as heterozygotes, sampling bias may be introduced as a result of undue attention being directed towards the families which carry mutant allelomorphs. A further source of inaccuracy arises from the fact that fertility is influenced by numbers of genetic factors additional to the one in question, and these may not be randomly distributed among unrelated individuals carrying the normal and mutant genes. Errors of this type can, to a large extent, be eradicated by the use of sib comparisons, but in this case further uncertainty exists as to whether or not the reproductive capacity of the 'normal' brothers and sisters is representative of that of the population as a whole.

Variations in the fitness conferred by different allelomorphs result in their existing at different frequencies, and it was to a formal mathematical analysis of the maintenance by selective forces of this type of polymorphism that Dr. A. R. G. Owen (University of Cambridge) addressed himself in a paper entitled "Mathematical Models for Selection". In this field, present studies relate exclusively to genes at a single locus, and for stability to be achieved in the relative frequencies of two or more allelomorphs it is necessary that each homozygote should have a fitness less than the average for the population as a whole. The frequency of each allelomorph is broadly related to the fitness which it confers, but when three or more are involved, complex relationships, not only between the viabilities of the various homozygotes but also between those of different heterozygotes, must be satisfied before a stable equilibrium can be achieved. Slight shifts in selective pressure can cause marked changes in the polymorphic balance, while selection acting differentially upon genotypes derived from the male or female parent may result in a dynamic polymorphism in which the frequencies of different allelomorphs vary continually without, however, any allele becoming extinct.

That the maintenance of polymorphism in the frequencies of human genes depends on selective factors now admits of little doubt, and it was in the contribution by Dr. P. M. Sheppard (University of Liverpool) that emphasis was laid on the fact that genes, the presence of which can easily be detected by analyses of characters apparently devoid of selective significance, often exert secondary effects which influence the fitness of the individual to an extent sufficient to establish a polymorphism. Among such genes, the factors which determine the blood groups are probably the best known. Possession of the gene for blood group A is associated with a tendency to develop cancer of the stomach, while the factor for blood group O is, in the presence of the 'non-secretor' gene, associated with an increased incidence of duodenal ulcer. Again, while individuals who are able to taste phenylthiocarbamide are predisposed to the development of diffuse goitre, those unable to taste this compound exhibit an increased incidence of nodular goitre.

In certain instances complex relationships between the selective significance of different series of allelomorphs arise as a result of interactions between the physiological characters which they influence. For example, the selective disadvantage which results from incompatibility between mother and fœtus in either the Rh or ABO series of allelomorphs is largely neutralized if the incompatibility exists in both series simultaneously.

Certain quantitative features (for example, skin colour) are known to have adaptive significance, while others (for example, intelligence) are correlated with fertility and viability. There would seem to be no reason to doubt that the selective forces thus set up have, by their action upon isolated populations, produced the well-defined differences which now exist between the major human sub-groups. In human populations, however, there are, as recently elaborated by Sir Julian Huxley, certain unusual selective forces in operation. These arise from man's unique capacity for abstract thought—a feature which is correlated with the marked cerebral enlargement that has occurred in the course of human evolution. Cerebral enlargement has, in turn, been associated with marked modifications in the cranial and facial skeleton, while concurrently there have arisen in the post-cranial skeleton numerous distinctive features consequent upon man's assumption of an upright posture.

The final paper in the symposium contained a general discussion of certain problems associated with the study of the evolution of these unique human features. Following a brief review of the various phases of the primate radiation between the Eocene and the present day, Dr. E. H. Ashton (University of Birmingham) submitted that as the numbers of available fossil primates are small, and as conspicuous gaps exist in the record of each sub-group of the order, little can be inferred about the anatomical nature of the immediate ancestors of *Homo sapiens*. As a corollary it was suggested that whatever significance may be attached to such controversial groups as *Oreopithecus* and the South African Australopithecinae, it is not feasible to assess the point at which the human stock, which does not appear in an undisputed form until part of the way through the Pleistocene, diverged from the apes, the first representatives of which date from the Lower Oligocene. Consequently, the rate of evolutionary change in each line is indeterminate.

One set of observations does, however, show that in the extant subhuman primates measurable amounts of morphological change can occur in exceptionally short periods of time. A colony of the West African green monkey (*Cercopithecus aethiops sabaeus*) which has been isolated for a mere hundred generations on the West Indian island of St. Kitts now differs significantly in cranial and dental features from the present-day African descendants of the parental stock. The St. Kitts monkey is now not only bigger, but also its cranial and dental dimensions are less variable than in the African variety. On the other hand, while its skull is less symmetrical, certain non-quantitative features of the teeth of the island

monkey are now more variable than in the mainland variety. Although the possibility cannot be excluded that this complex of change has resulted from the direct action of a changed environment on an unaltered genetic constitution, parallels with complexes of change recorded in laboratory experiments with lower animals suggest that the differences may have, as a basis, changes in systems of multiple genes. In this case, the observations would represent an example, at present unique, of the effect of selective forces upon a primate population.

E. H. ASHTON

WOMEN IN ENGINEERING

PROBABLY the most persuasive case for the employment of professional women in industry has been made by the Women's Engineering Society. Unlike other women advocates who rely either on wistful laments or on emotional over-statements of unestablished truths, the Women's Engineering Society bases its case on hard-won knowledge of industry and on the records of those courageous and enterprising women engineers who have already made successful careers for themselves in industry. In a booklet prepared by members of the Careers Panel of the Society, it is shown that there is now no reason why a girl with talent and determination should not embark on an engineering career with every prospect of success (Training and Opportunities for Women in Engineering, 25 Fouberts Place, London, W.1. 3*s.* 6*d.*). She is advised, however, to equip herself fully with formal qualifications, like membership of professional institutions and those obtained by examination, such as a university degree in engineering or a Higher National Certificate. "Engineering training has two distinct components, theory and practice, and both are equally necessary to the would-be engineer. The former can be obtained in Universities and Technical Colleges, while, for most branches of the profession, the best practical training is provided in industry." It is in obtaining this practical training that the girl student may find herself at a disadvantage compared with her brother. Entry into certain branches of engineering is easier than into others, and there is more prejudice against the employment of women in certain positions than in others. The new branches of engineering such as aeronautics, electrical and electronic engineering, or heating and ventilating, offer an easier entry to women than do the older branches such as marine or locomotive engineering, naval architecture or civil engineering.

There is still a prejudice against putting women in control of large numbers of men, and few firms the employees of which are mostly male would consider appointing a woman as works manager or foreman. There is far less prejudice against the employment of women in scientific work, design or research.

The booklet describes the training and qualifications required in many branches of engineering as well as the posts available when training is complete.

WATER POLLUTION RESEARCH, 1957*

MUCH of this tightly packed report will be of interest only to those who are directly concerned with sewage treatment and pollution, and the thirty-two papers published by members of the staff during the year have nearly all appeared in technical journals. Some of the work is of wider appeal, and merits fuller mention than the rest in a journal of general science such as *Nature*.

Various calculations have been made to find the most economical way of improving the Thames estuary. Aeration of some of the worst inflows has been suggested, but it is shown that the effect of this would not be great. An increase in temperature would lead to an immediately greater oxygen deficit but a corresponding amelioration farther down the river. It has been found that, especially at higher temperature, nitrate may be reduced before the concentration of oxygen approaches zero, a hitherto unsuspected complication in calculations of this kind. Even after the completion by the London County Council in about 1962 of alterations and extensions to its sewage works, the Thames will still be foul. Sulphide, perhaps, will no longer be formed in the central reaches of the estuary, but oxygen concentration will be low.

Fig. 13 of the report shows how oxygenation of water passing over a weir increases with the height of the weir, rapidly at first but gradually more slowly, a 9-foot weir, the highest tested, being only slightly more advantageous than one 8 feet high. The effect depends also on the depth of the basin into which the water falls; with a 5-foot fall the concentration of oxygen increases quite markedly up to a depth of 8 inches, but thereafter is the same for all depths. Another experimental set-up of general interest is the channel for studying temperature gradients. It is 500 feet long and is made by setting baffles across a tank. The object is to study the behaviour of fish in a temperature gradient; but first it will be necessary to study the nature of the gradient under different conditions of flow, humidity and initial temperature. Some figures are presented here, but it is hoped that more will be forthcoming and their relation to the results of theoretical calculations discussed. The continuous recorder for dissolved oxygen, on its way to becoming a standard instrument, has been developed and improved by the incorporation of a device for automatic temperature compensation, which is described.

The amount of effluent necessary for a satisfactory test of toxicity is inconveniently large if the fish used is more than about 1 inch long, and foreign fish have been used since no British species is as small as this when adult. The apparatus designed for routine tests is described and figured. Zinc is shown to be toxic at lower concentration in soft than in hard water, rainbow trout, for example, dying in less than three days in 0·5 p.p.m. zinc in soft water and sur-

* Department of Scientific and Industrial Research. Water Pollution Research 1957: The Report of the Water Pollution Research Board with the Report of the Director of the Water Pollution Research Laboratory. Pp. iv+100+4 plates. (London: H.M. Stationery Office, 1958.) 6*s.* net.

viving ten days in six times that amount in hard water. Experiments with a radioactive tracer suggest that the effect of the zinc may be internal and not merely on the gills as hitherto believed.

Various mixtures likely to be produced by coke ovens are more toxic than pure phenols, and their effects are enhanced by low oxygen concentration. Biological treatment is sometimes successful, but not when substances containing much ammonia are present. Cyanide, too, has been successfully broken down in a biological filter, and experiments have been carried out on an anaerobic digestion process for certain trade wastes. It has been found a satisfactory method of dealing with the effluents from slaughter-houses and whisky distilleries.

The nature and concentration of the constituents of domestic sewage, about which little is known, are under investigation. It now seems clear that synthetic detergents reduce the rate at which oxygen is absorbed in the activated sludge process, and this may account for reports of decreased efficiency of certain plants in recent years. T. T. Macan

CHEMICAL DESTRUCTION OF MATURE PERITHECIA OF *MYCOSPHAERELLA PINODES*

By M. V. CARTER

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RECENT research work with dinitro-ortho-cresol, pentachlorophenol (and their sodium salts) and phenyl mercury compounds as eradicant fungicides has been aimed mainly at preventing the normal maturation of ascocarps of various fungal pathogens, as distinct from destroying mature ascocarps. Pathogens in which ascospore discharge has been controlled successfully by the application of these compounds prior to maturation of the perithecia apparently all belong to the group of Ascomycetes which complete their life-cycles during a long over-winter saprophytic phase in fallen leaves, mummified fruits, or branch cankers, for example, *Venturia inequalis*[1], *Pseudopeziza ribis*[2], *Sclerotinia* spp.[3], *Nectria galligena*[4].

In South Australia, where large areas of garden peas for fresh marketing are grown under sprinkler irrigation in districts of low natural rainfall (12 in. or less per annum), extensive damage to crops by *Mycosphaerella pinodes* is common. Under optimum conditions, mature perithecia of this fungus may be produced within two weeks from the time of infection: there are thus many generations of ascospores during a single pea-growing season.

Phenyl mercuric chloride was found to be ineffective in destroying mature perithecia of *M. pinodes* when applied at a concentration of 0·1 per cent, as used for autumn spraying for eradication of *V. inequalis*.

In the first series of laboratory tests with pentachlorophenol, an oil-and-water emulsion containing 0·75 per cent of the chemical was applied by means of a 'Rega' hand atomizer to a series of 5–10 gm. samples of heavily infected pea straw from the 1957 crop, collected from the field in February 1958. Control samples were treated with distilled water. Beginning two days after the treatments were applied, and at weekly intervals thereafter for the next seven weeks, ascospore discharge was tested by immersing each sample in water for 5 min., draining for 5 min., and suspending in a wire basket under a bell-jar 6–7 in. above the orifice of a Hirst-type spore impactor[5], which was then operated for 1 min.

Table 1. Numbers of Ascospores* of *Mycosphaerella pinodes* discharged from Pea Stubble Samples after Treatment with 0·75 per cent Pentachlorophenol

Days after treatment	Control (water only)					0·75 per cent pentachlorophenol				
	1	2	3	4	5	1	2	3	4	5
2	869	1,056	1,159	622	327	68	3	17	12	3
9	155	1,999	1,625	1,126	711	40	1	0	12	0
16	488	637	2,003	1,129	489	4	2	2	0	1
23	2,056	3,612	8,622	5,672	808	9	0	2	7	4
30	843	850	840	2,310	345	9	2	0	3	2
37	1,272	1,758	1,559	1,365	792	10	9	0	79	0
44	813	977	1,881	706	992	4	0	0	11	0
51	286	1,517	248	206	34	2	1	1	2	0
Totals	6,782	12,406	17,937	13,136	4,498	146	18	22	126	10

* Each count is the sum of 10 traverses across the zone of spore deposit on a microscope slide, using a magnification of 480

Table 2. Numbers of Ascospores* of *Mycosphaerella pinodes* discharged from Pea Stubble Samples after Treatment with Pentachlorophenol at various Concentrations

Days after treatment	Control (water only)			Pentachlorophenol (per cent)												
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
2	598	2,006	392	39	68	34	3	0	0	0	0	0	0	3	0	1	0	0
9	8,180	2,510	1,860	125	2	37	0	0	0	0	0	0	0	0	0	0	0	0
16	Not counted			27	3	1	0	0	0	5	0	0	0	0	0	0	0	0
23	3,988	> 10,000	4,094	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
30	> 10,000	> 10,000	> 10,000	0	4	5	0	0	0	0	0	0	0	0	0	0	0	0
Totals	> 22,000	> 24,000	> 16,000	191	81	77	3	0	0	5	0	0	0	3	0	1	0	0

* Each count is the sum of 10 traverses across the zone of spore deposit on a microscope slide, using a magnification of 480

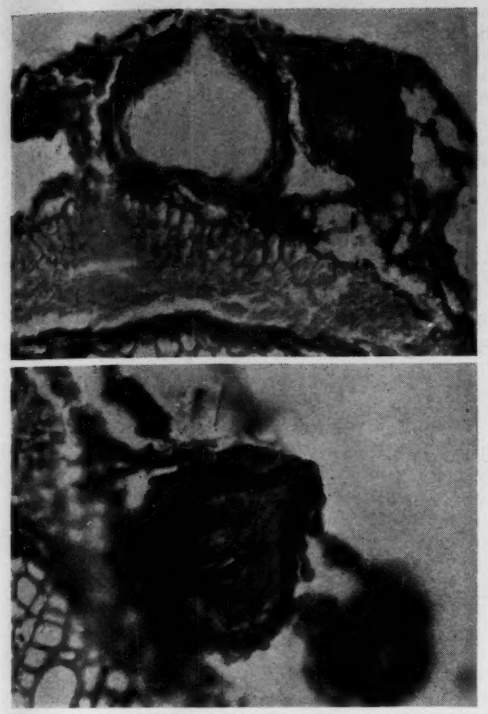

Fig. 1. Top, perithecia of *M. pinodes* treated with 0·75 per cent pentachlorophenol; bottom, normal (untreated) perithecium of *M. pinodes*

The spore counts given in Table 1 suggested that this concentration of pentachlorophenol had a powerful fungicidal effect on mature perithecia of *M. pinodes*, but that the method of application had not given complete coverage.

The second series of laboratory tests was designed to determine the effect of a range of concentrations of pentachlorophenol on 10-gm. samples which were momentarily immersed in the emulsion in order to ensure complete coverage. Spore discharge was assessed in the same way, beginning on the second day after treatment and continuing thereafter at weekly intervals for five weeks. Spore counts are given in Table 2, and these indicate a highly efficient kill of perithecia with all concentrations of pentachlorophenol down to 0·2 per cent.

After each of the first four discharge tests, the samples were allowed to dry in air. After the fifth discharge, all the samples were showered with ascospores of *M. pinodes* and incubated moist in closed containers at room temperature to determine whether recolonization by the fungus could occur at this stage. Straws untreated with pentachlorophenol but steam-sterilized were also subjected to a similar inoculation and incubation.

A very heavy mycelial growth was present on the steam-sterilized straws after incubation for five days; that on the unsterilized untreated controls was less conspicuous, possibly due to partial inhibition by strong bacterial growth. A few isolated colonies were noted on all the samples treated with pentachlorophenol except those which had received the 2 per cent treatment.

In order to examine histologically the effect of pentachlorophenol on the perithecia, representative straws from 0·75 per cent pentachlorophenol and from control samples were embedded in paraffin wax and sectioned by microtome at 10μ. The chemical completely destroyed the contents of the perithecia, which appeared either empty or with a few disorganized remains in the asci, as shown in Fig. 1 (top). Sections of normal untreated perithecia are shown in Fig. 1 (bottom).

Preliminary tests have shown that dinitro-orthocresol (0·2 per cent) and dinitro-secondary butylphenol (0·2 per cent) may be expected to give similar results.

Field experiments with certain of these chemicals are proceeding; but observations to date indicate that the technical difficulties of obtaining a sufficiently complete spray coverage of the pea stubble will present a serious obstacle to successful application of the method for field control of the pathogen.

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OXIDATION OF ASCORBIC ACID AND SIMILAR REDUCTONES BY NITROUS ACID

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AND

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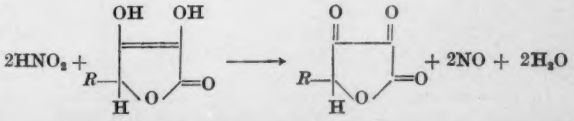
THE reaction between ascorbic acid and sodium nitrite or nitrous acid was first observed by Karrer and Bendas[1]. This reaction is general for reductones (that is to say, enediols stabilized by conjugation to a carbonyl or similar group)[2,3]; it has the characteristics of a typical oxidation-reduction process, and gives quantitative formation of nitric oxide and dehydro reductone. For example:

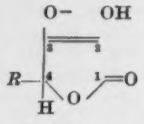


(Ia), Ascorbic acid ($R = CH_2OH.CHOH—$)
(Ib), Phenyl hydroxytetronic acid[2] ($R = C_6H_5—$)

(IIa), ($R = CH_2OH—CHOH—$)
(IIb), ($R = C_6H_5—$)

The optimum conditions for these reactions (in aqueous solutions at pH < 5) are similar to those in which nitrosation at nitrogen and oxygen occurs[4,5], and we sought and have found a parallel between the oxidation of reductones, and the diazotization of aromatic amines[4], and the exchange of oxygen atoms between water and nitrous acid[5].

The compounds (*Ia*) and (*Ib*) have characteristic absorptions[6] which are more intense than those of the dehydro reductones (*IIa*) and (*IIb*) and of nitrous acid, and the reaction can be followed by spectrophotometric methods. The 3-hydroxyl group of (*Ia*) and (*Ib*) is acidic ($pK_a \sim 4$), while that on C-2 is enolic ($pK_a \sim 12$)[7]. Thus at pH < 5 the acid (I) and its mono-anion (III) co-exist.



(III)

The kinetics of the oxidation of ascorbic acid (and to a limited extent of phenyl hydroxytetronic acid (*Ib*)) have been examined in detail at 0° C. in aqueous dioxan. A few runs were made in water, but in some conditions the reaction in water is too fast for convenient measurement. In all cases the concentration of the reductone ($0{\cdot}1$–$0{\cdot}2 \times 10^{-3}$ M) was much less than that of the nitrous acid ($0{\cdot}8$–$8{\cdot}0 \times 10^{-3}$ M).

With sodium nitrite in excess over nitrous acid (pH 3–4 in water) we observe the rate-law for reactions in both water and aqueous dioxan:

$$v = k_2 [HNO_2]^3$$

The kinetic form of an individual run is of zeroth-order in reductone and the rate is almost independent of the nature and concentration of the reductone:

(*Ia*), $10^3 k_2 = 1{\cdot}7$ (mol.$^{-1}$ l.sec.$^{-1}$)
(*Ib*), $10^3 k_2 = 1{\cdot}5$ (mol.$^{-1}$ l.sec.$^{-1}$)
(0° C.; dioxan : water :: 40 : 60 v/v)

Following the interpretation given to such a kinetic form in the diazotization of the aniline[4], we conclude that the step *determining the rate* of the reaction is the formation of dinitrogen trioxide.

Reaction path A:

$$2HNO_2 \rightleftharpoons H_2NO_2^+ + NO_2^- \quad (1)$$

$$H_2NO_2^+ + NO_2^- \rightleftharpoons N_2O_3 + H_2O \quad (2)$$

$$N_2O_3 + \text{reductone} \rightarrow \text{intermediate (IV)} \quad (3)$$

$$\text{(IV)} \xrightarrow[\text{(fast)}]{\text{nitrous acid}} \text{(II)} \quad (4)$$

In this acidity region most of the reductone is present as a mono-anion (III); we assume that the dinitrogen trioxide reacts rapidly with this mono-anion (step 3), to give an intermediate (IV), which then reacts rapidly with a further nitrous acid species to give the final products. (The probable nature of the intermediate is discussed below.) This kinetic scheme requires that the rate of reaction of the reductone in water should be close to that of the zeroth-order diazotization of aniline[4], and the oxygen exchange of nitrous acid via dinitrogen trioxide[5]: this is so within the limits of experimental uncertainty.

$k_2 = 0{\cdot}49$ (mol.$^{-1}$ l.sec.$^{-1}$) (oxidation of (*Ia*))
$= 0{\cdot}85$ (mol.$^{-1}$ l.sec.$^{-1}$) (diazotization)[4]
$= 0{\cdot}53$ (mol.$^{-1}$ l.sec.$^{-1}$) (oxygen exchange)[5]
(0° C.; water)

At the other extreme of our acidity-range (with $[HClO_4] \gg [HNO_2]$) we observe a different kinetic form:

$$v = k_2^{0H} [H^+] [HNO_2] [\text{ascorbic acid}];$$
$k_2^{0H} = 7{\cdot}5$ (mol.$^{-2}$ l.^{2} sec.$^{-1}$)
(0° C.; dioxan : water :: 40 : 60 v/v)

(So far, this region has been explored only for the oxidation of ascorbic acid in aqueous dioxan.) With an excess of perchloric acid (about $0{\cdot}1$–$1{\cdot}0$ M) the concentration of ascorbate ion is very low, and we consider the mechanism to be a slow reaction between the nitrous acidium ion (V) and ascorbic acid.

Reaction path B:

$$H^+ + HNO_2 \rightarrow H_2NO_2^+ \text{ (V)}$$
$$\text{(V)} + \text{ascorbic acid} \rightarrow \text{intermediate (IV)} + H^+$$

followed by a rapid reaction of the intermediate (IV). This process has its analogy with N- and O-nitrosations, for example, the diazotization of aromatic amines in acid[4], and the acid catalysed hydrolysis of alkyl nitrites[8].

In the acidity-range between those which show mechanisms *A* and *B* there is a region in which the kinetics are of mixed order. Part of the reaction proceeds by mechanism *B*, but there is also a rate term which is second order in nitrous acid and first order in stoichiometric reductone. A similar kinetic form has been observed for reactions between nitrous acid and both aliphatic and aromatic amines[4,9]. It arises because in this region dinitrogen trioxide is in facile equilibrium with nitrous acid (steps 1 and 2 of mechanism *A*), but the proportion of the highly reactive reductonate ion is now very low ($< 0{\cdot}1$ per cent), and so the reaction with dinitrogen trioxide (step 3 of path *A*) is slow. A detailed examination of the effect of changes in acidity and nitrous acid concentration upon the reaction-rate between nitrous and ascorbic acids shows that in the region $[H^+] = 10^{-4}$–10^{-3} M, dinitrogen trioxide reacts with both ascorbic acid and ascorbate ion, and it is possible to estimate the relative reactivities towards dinitrogen trioxide:

$$v = [HNO_2]^3 \{k_3^0 [\text{ascorbic acid}] + k_3^- [\text{ascorbate}]\}$$

$k_3^0 = 73$ (mol.$^{-2}$ l.^{2} sec.$^{-1}$); $k_3^- = 1{\cdot}15 \times 10^5$ (mol.$^{-2}$ l.^{2} sec.$^{-1}$) (0° C., dioxan : water 40 : 60 v/v).

Thus we have reactions of the powerfully electrophilic nitrous acidium ion with the undissociated reductone, and of the weakly electrophilic dinitrogen trioxide with both the undissociated reductone and its more reactive anion.

Chloride and bromide ions catalyse the oxidation of ascorbic acid by nitrous acid by forming nitrosyl halides, which are themselves powerful nitrosating agents[4].

$$H_2NO_2^+ + X^- \rightleftharpoons NOX + H_2O$$

$$NOX + \left\{\begin{matrix}\text{ascorbic acid}\\ \text{ascorbate ion}\end{matrix}\right\} \rightarrow \text{intermediate (IV)} + \left\{\begin{matrix}HX\\ X^-\end{matrix}\right\}$$

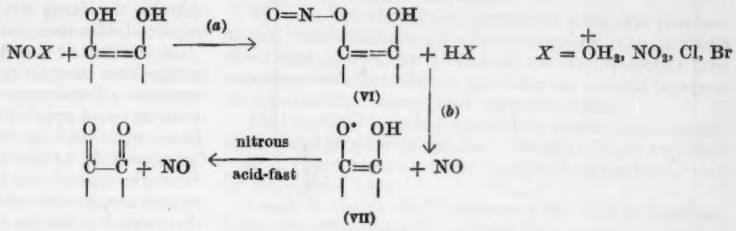
$(X = Cl, Br)$

From our kinetic results we can calculate specific rate-constants for the processes, and estimate the relative reactivities of various species towards dinitrogen trioxide and the nitrous acidium ion. In making these calculations we have ignored effects due to activity changes; these should not be large because the ionic strengths of the solutions are low, and approximately constant. Some of the numerical values are uncertain, because they are derived from small differences between large quantities.

We can formulate the reaction between a nitrosating agent and a reductone in various ways. Perhaps the simplest is a preliminary electrophilic attack upon the reductone (*a*), with formation of a nitrite (VI), which then decomposes (*b*).

It is, of course, possible that steps (*a*) and (*b*) may be synchronous, and the process would then be considered as a transfer of a single electron to the nitrosating agent. In either event we conclude that the first step of reaction between a nitrosating agent and a reductone, forming the semiquinone (VII) (which may be identical with the above-mentioned 'intermediate' (IV)), is followed by a rapid reaction between (VII) and nitrous acid, or some species in equilibrium with it.

It seems to us that there is, therefore, a very close similarity between this oxidation – reduction reaction and the well-characterized heterolytic nitrosations by electrophilic reagents.



This work forms part of a research programme on reductones, sponsored by the Schweizerischer Nationalfonds zur Förderung der wissenschaftlichen Forschung, to which we express our thanks. A full account of the present work will be given in *Helvetica Chimica Acta*.

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A TWO-DIMENSIONAL PAPER CHROMATOGRAPHIC METHOD COMBINING ION-EXCHANGE AND PARTITION TECHNIQUES

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ALTHOUGH the two-dimensional paper chromatographic method has been successfully applied to separations involving a wide range of substances, improvements and modifications are continually being proposed to make this technique even more discriminating.

Separations can often be improved by increasing the complexity of one or more of the conditions under which a chromatogram is developed, as, for example, in the use of three- or four-component solvent mixtures. On the other hand, the use of simple conditions to increase the reproducibility is often insufficient to effect an adequate separation. Thus, some approach between the two extremes has to be adopted. The present method, however, offers a means of increasing reproducibility in addition to separability.

This new approach to paper chromatography comes as a result of the development of a range of Whatman ion-exchange celluloses in these Laboratories. These new materials have been prepared by introducing acidic or basic groups into the cellulose molecule such that, under favourable conditions, ion-exchange involving these groups will be the dominating factor in a chromatographic separation[1]. Where, however, it is possible to suppress the activity of these groups such that ion-exchange is no longer the dominating factor, any chromatographic separations under such conditions will be largely as a result of a partition-type mechanism similar to that on unmodified cellulose. On the one material, in paper form, therefore, it is possible to combine ion-exchange and partition techniques in the form of a two-dimensional chromatogram, and this very simply is the basis of the method described below.

The ion-exchange materials investigated contained medium or weak strength functional groups such that where necessary their ion-exchange properties can be suppressed to varying extents by addition of acid or alkali to a developing organic solvent. Details of some separations investigated are as follows.

(1) Phosphorylated cellulose, containing dihydrogen phosphate groups, was used in the form of its mono-ammonium salt. A mixture of copper, manganese, cobalt, cadmium, iron, bismuth, zinc and mercury was applied as a spot near one corner of a

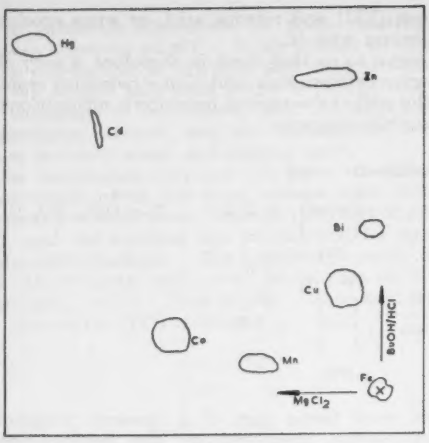

Fig. 1

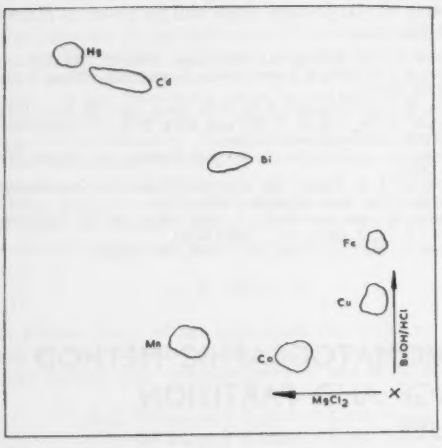

Fig. 2

14-in. square sheet of paper. The organic phase of a mixture of butanol saturated with 2 *N* hydrochloric acid was used as first solvent in a downward direction, after which the sheet was dried over ammonia to neutralize excess acid and convert the paper to its original form. The second development, in a downward direction at right angles to the first development, was with *N* magnesium chloride solution. The choice of this eluting agent stems from its successful application by other workers[2]. The separated spots were detected by spraying with a pentacyanoammineferrate/rubeanic acid complex, which produces characteristic colours with a large range of cations[3].

Fig. 1 is a map of the spots on the completed chromatogram. The position of the spots in the first direction is similar to the positions expected on unmodified cellulose. Iron occupies an anomalous position possibly due to complex formation between it and the phosphate groups on the paper[4]. The flat shape of the cadmium spot in the magnesium chloride direction is probably due to the occurrence of a magnesium – ammonium boundary at this point.

(2) Carboxylated cellulose (type 2) containing primary carboxyl groups was used in its hydrogen form. A mixture of copper, manganese, cobalt, cadmium, bismuth, iron and mercury was applied as a spot near one corner of a 14-in. square sheet of paper. Development was carried out in two directions, using the same solvents and technique as in (1).

Fig. 2 is a map of the spots on the completed chromatogram. In the first direction, iron has assumed a more typical position, but in the magnesium chloride direction the position of bismuth is not that expected of a trivalent ion.

(3) Aminated cellulose containing aminoethyl groups was used in the form of its hydrochloride. A mixture of copper, cadmium, lead, bismuth and mercury was applied as a spot near one corner of a 14-in. square sheet of paper. The first solvent was a butanol–2 *N* hydrochloric acid mixture as before. After drying at room temperature, without addition of ammonia, the chromatogram was developed in the second direction with *N* hydrochloric acid[2]. The positions of the spots were revealed by spraying with ammonium sulphide solution.

Fig. 3 is a map of the spots on the completed chromatogram. R_F values in the first direction are lower than in 1 and 2 and it is tempting, from the position of the spots, to assume a mechanism largely of partition type with the lower R_F values being due to the increased polarity of the cellulose. However,

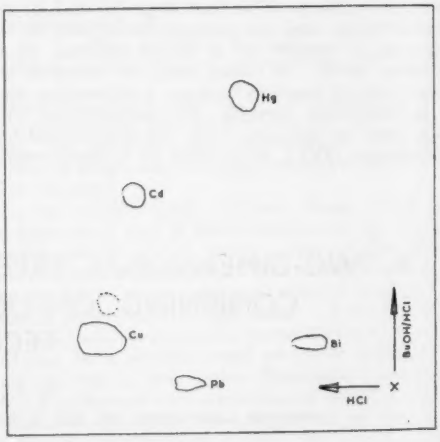

Fig. 3

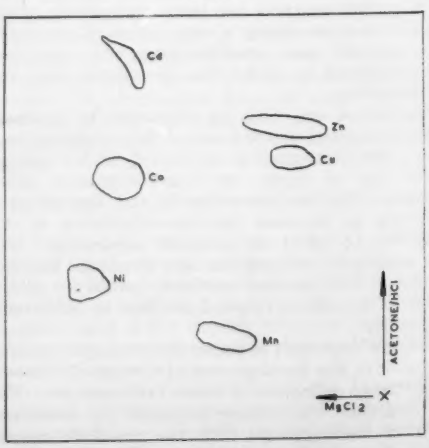

Fig. 4

in this particular case where the ionization of the functional groups is not suppressed it is possible that the mechanism is of a more complicated nature. The metals separate as their anionic complex chlorides in the second direction. The spot represented by the dotted outline was due to a trace of iron in the original mixture.

Slight variation of the relative positions of the various cations on the different materials in the butanol–hydrochloric acid direction is to be expected, the weak carboxyl exchanger giving a separation closest to that obtainable on unmodified cellulose. From Figs. 1, 2, and 3, however, it can be seen that good separations can be obtained on relatively small areas of paper. Fig. 4, for example, illustrates a separation of six metals on an 8-in. square of phosphorylated paper by an ascending technique, using an acetone–hydrochloric acid–water (50 : 5 : 5) mixture in the first direction and N magnesium chloride in the second.

The advantages of the increased separation by the above method will be emphasized in the separation of a series of related substances where it is common in conventional two-dimensional paper chromatography to obtain separations in which the majority of the spots are concentrated in one diagonal half of the paper, since in many cases the relative R_P values of the series of substances are similar in a whole range of different organic solvents.

To sum up, therefore, compared with the conventional two-dimensional chromatogram, the method described above, by virtue of the incorporated ion-exchange characteristics, provides an overall increase in separability, speed and reproducibility.

This method is being applied to amino-acid separations with promising results. Details of this, together with a fuller report on the inorganic separations, will be published later.

I wish to thank the Directors of W. and R. Balston, Ltd., for permission to publish this work.

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NATURE OF THE VIBRATO AND THE CONTROL LOOP IN SINGING

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ANY attempt to analyse the control mechanisms in the human operator is greatly facilitated if we can control all the information which is fed from the output back into the input. But whereas in most skills proprioception, which is resistant to such control, is of importance, in singing the role of the auditory pathway is paramount. This can readily be heard if a subject is asked to sing a simple musical scale when a strong masking noise obliterates his hearing of his own performance. He will sing badly out of tune.

As a result, the investigation into the control mechanisms of skill has shed some light on the cause of fluctuations in frequency in the singing human voice. It has long been known that when a subject attempts to sing a steady note there is a periodic fluctuation in frequency of approximately 5–6 cycles per second. Suspecting that this tremor might represent the oscillations due to a control mechanism utilizing auditory feedback, the senior author began a series of experiments, now concluded by both of us, which show that this supposition is at least partially the case.

We find that if a delay is interposed between the subject's singing a note and afterwards hearing it, the time taken for one cycle of fluctuation increases directly with the interval of incorporated delay, and that the same is true of the amplitude of the deviation from the note he is attempting to sing. These points are illustrated in Figs. 1 and 2, respectively. Records of the frequency fluctuations were obtained through an audio-frequency meter devised by the senior author[1]. Samples of these records with no artificial delay and with 0·366 sec. delay are shown in Fig. 3. The voice was delayed by the procedure of recording on tape at one point and taking off at an adjacent point through another lead. The output was then greatly amplified and fed back to the subject through a pair of earphones. The loudness of the note fed back in this way was sufficient to mask the sound of the subject's own undelayed voice.

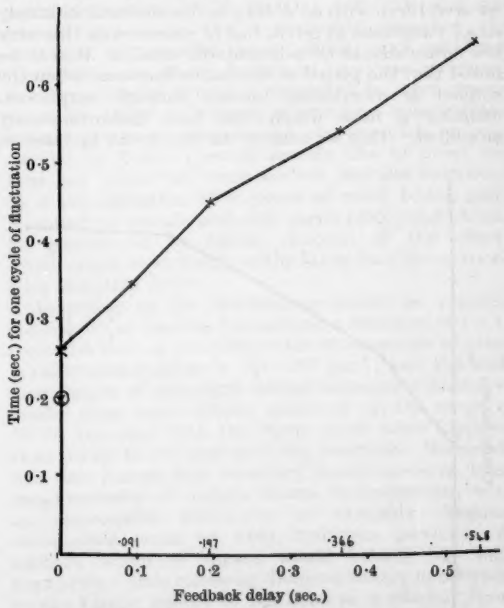

Fig. 1. Average time taken for one cycle of fluctuation under varying feedback delays. Each point represents an average for thirteen subjects. The encircled point on the abscissa gives the average time for the normal voice. The first point of the graph gives the average for monitoring through earphones without an incorporated delay

The importance of the findings is as follows.

The voice is largely controlled by the auditory message generated by it (this probably only applies

to the fine frequency control of the voice, for at very long delays the deviations from the desired note do not reach the amplitude predicted on this mechanism alone).

The control does not seem to be applied in proportion to the magnitude of the error as the correction made in response to the error continues smoothly until it has led the subject into an error of opposite sign which is of equal amplitude. Further experiments to check this view have already been undertaken with an artificial larynx where the amount of change perceived by the subject can be instantaneously exaggerated to him. Using this type of apparatus, if we invert the direction of change it should be possible to discover whether the sign as well as the magnitude of error is disregarded by the mechanism determining the corrective movements. We should then be able to speculate more accurately about the mechanisms of skilled performance generally.

It appears that the time taken to react to an error in this kind of skilled performance is rather lower than might have been suspected from the existing data on reaction times and refractoriness. It must be remembered that a subject can only start reacting to his own error when the note produced by the error has exceeded the difference threshold between itself and the note he is aiming to sing. From the records which we have obtained of the subject monitoring his own performance without the intermediacy of headphones (that is, in the natural way) we conclude that the subject's reaction time is 0·10 sec., even if we credit him with an ability to discriminate infinitely small variations in pitch, but of course even this very low figure should be substantially smaller. It is to be noted that the period of oscillation increases when the subject is monitoring himself through earphones, utilizing a note which has been instantaneously amplified. This we take to be due to an increase in the differential threshold in pitch in the monitoring process when the subject is presented with a sound less familiar to him than the sound of his natural voice. (This observation tends further to substantiate our claim that in the frequency vibrato we are dealing with a phenomenon of auditory feedback control.) The mean auditory reaction usually quoted[2] is 0·15 sec. Such a time increases in the ordinary situation if the signals follow close on each other, as has been shown by R. Davis[3], following the work of Craik and Welford on serial reaction times. However, the corrections we note are often obscured by a higher-frequency tremor, and this will make our estimate inaccurate.

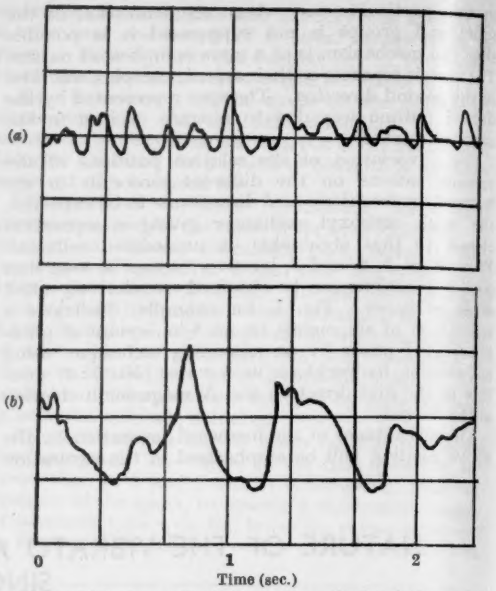

Fig. 3. (*a*) Frequency fluctuations of normal voice singing a note of 180 c./s.; (*b*) fluctuations of same voice with feedback delay of 0·366 sec. (It can be seen that in both records there are superimposed higher-frequency tremors of unknown origin)

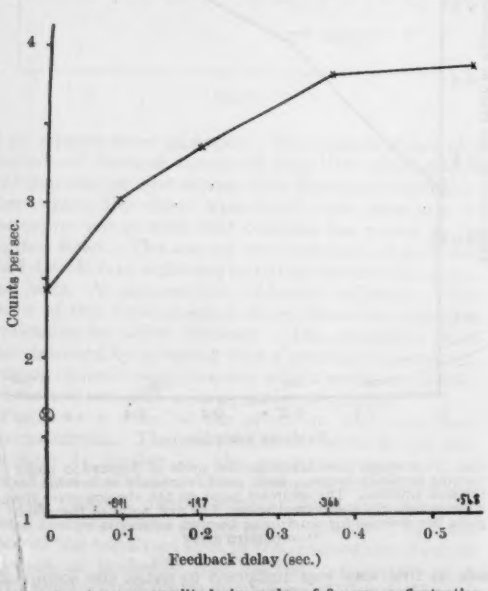

Fig. 2. Average amplitude in cycles of frequency fluctuation under varying conditions of delay. The encircled point on the abscissa gives the average for the normal voice. The first point of the graph gives the average for monitoring through earphones without an incorporated delay. (All points give averages for thirteen subjects)

It also appears that the corrections are made to differences in pitch which would, from the results of the usual experiments, be below the threshold of discrimination. It is hoped that with the method of the artificial larynx outlined above it may be possible to determine more precisely both the size of reaction time to a signal in this situation and the amount of frequency change necessary to trigger off such a control movement. At present we can only say that the corrective movement occurs when the deviation has reached only a matter of 1·6 c./s. when singing a 120 c./s. note under normal conditions. This fixes the largest possible threshold if we assume that the reaction time is vanishingly small. Both the small reaction time and threshold may be due to the high probabilities of the signal and this requires to be investigated further.

We are indebted to the Medical Research Council for grants in aid for apparatus and a grant for scientific assistance.

We should also like to thank Prof. R. C. Oldfield for the encouragement he has given us and for the facilities he has granted us in his laboratory.

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LETTERS TO THE EDITORS

ASTRONOMY

Origin of the Lunar Craters and Maria

RECENT observations by Kozyrev (private communication) of transient emission bands of the carbon molecule in the spectrum of the central peak of the lunar crater Alphonsus have strikingly re-opened the age-old problem of the origin of these most characteristic landmarks of the lunar surface; and the dilemma between the volcanic and impact phenomena appears once again to face us in a new form. While more definite conclusions bearing on the first alternative will have to await a determination, now under way, of the temperature of the carbon gas discharge in Alphonsus from the relative intensities of the observed Swan bands of its spectrum, it may be pertinent to point out at this time that the impact theory of the origin of the principal surface features of the Moon may require re-examination and re-assessment also on completely independent grounds, some of which will be discussed below.

According to the impact hypothesis, widely held in recent time, most—if not all—lunar craters were formed by solid bodies (meteorites, or asteroids) impinging on the Moon with cosmic velocities. What the protagonists of this hypothesis have actually accomplished so far, however, has been to make it plausible that impacts of meteorites of sufficient kinetic energy *may* have produced craters similar to those observed on the Moon at the point of impact, and that such meteorites *may* have collided with the Moon in the course of its long past; but little or no attention has been paid so far to the phenomena which such impacts would be bound to produce on the Moon as a whole.

In order to consider this point, let us recall that, according to Baldwin[1], kinetic energies of the order of 10^{26}, 10^{27} and 10^{28} ergs are necessary to produce impact craters of 20, 40 and 80 miles in diameter. As the impinging body would penetrate at least a few hundred yards into the lunar crust before total vaporization of its mass and the ejection of crater walls by the ensuing explosion, the whole phenomenon would be bound to produce also a 'moonquake', characterized by a very shallow epicentre, with approximately one-half of the kinetic energy of the impinging body necessarily converted into seismic waves.

In order to appreciate the seriousness of this point, let us recall that, according to the latest survey by Gutenberg[2], the largest and most destructive earthquakes experienced so far entail an energy release of the order of 10^{25} ergs only—that is, one thousand times less than that of a hypothetical 'moonquake' accompanying the origin of (say) the crater Alphonsus (the diameter of which is approximately 80 miles). When one considers the fact that there are more than 10^5 craters with diameters in excess of one mile on the visible hemisphere of the Moon alone, and that the largest among them possess diameters in excess of 150 miles, one is bound to question how any steep mountains or ridges anywhere on the Moon could have survived such a long series of sudden and devastating disturbances.

Of the different types of seismic waves which are bound to be excited by impact of external particles on the solid globe of the Moon, the Rayleigh surface waves are of particular interest in this connexion. According to Bullen[3], the terrestrial rate of damping of these waves is such that their amplitudes are reduced to approximately one-third over a distance of 5,000 km. As the lunar circumference is equal to only 10,921 km., the Rayleigh waves produced by meteor impact on any point of the lunar globe should converge on the antipodal point from all directions, with about one-third of their original amplitudes, carrying a total energy of probably not less than one order of magnitude smaller than that of the original impact. While the focusing properties of the lunar sphere may be blurred to some extent by surface irregularities, one is bound to inquire as to the type of phenomena—possibly observable—which an impact, sufficiently energetic to produce a crater on the spot, should also cause at the antipodal point; and, needless to stress, this question remains so far unanswered.

All existing discussions of the impact origin of the principal features of the lunar surface have, moreover, limited themselves to investigating the effects of collisions with *solid* bodies (like meteors, or small asteroids) which could account not only for the craters themselves but conceivably also for the existence of extended lunar plains (such as Mare Serenitatis, or Mare Imbrium)—a view proposed first by Gilbert[4] and ably defended in more recent years by Urey[5]. Without wishing to question the impact effects of low-velocity planetesimals as considered by Urey, I would merely like to point out that any theory of lunar surface features restricted to a consideration of impacts of solid bodies only is bound to remain seriously incomplete, and should be generalized by taking account of the effects which could be wrought on the lunar face by collisions with *cometary heads*.

According to the statistics available at present, comets are at least as frequent at a distance of 1 A.U. from the Sun as are meteorites or asteroids of comparable masses (that is, 10^{16}–10^{18} gm.); and the wide distribution of cometary orbital elements is bound to render their high-velocity collisions (in the range of 30–70 km./sec.) with the Moon much more frequent than would be the case with the asteroids. Moreover, it is now known that cometary heads represent loose conglomerates of mainly frozen hydrocarbons, with an appreciable admixture of unstable chemical compounds (such as solid hydrogen peroxide, or azides[6]) which on impact would behave like high explosives—thus releasing chemical energy in addition to the kinetic energy of the head as a whole. Now, unlike a solid meteorite, cometary heads possess no tensile strength, and their impact on the Moon would not indent the lunar surface to any appreciable extent: instead, it would volatilize completely at once and envelop, for a short time, the surrounding region in a slipstream of hot gas dispersing into vacuum.

Quite apart from the chemical binding energies, the kinetic energy of a major comet alone is a quantity of the order of 10^{31} ergs which—if it could be converted

totally into heat—would be equivalent to 2×10^{23} calories. If we now assume that, reasonably enough, 2,000 calories are necessary to melt 1 gm. of lunar matter (of density about 3 gm./cm.^{3}) into fluid lava, a single cometary impact of this type could provide some 10^{20} gm. of lava, capable of covering the 400,000 km.^{2} area of Mare Imbrium to a uniform depth of some 100 m. This, I suggest, may be another explanation of the origin of lunar maria, accounting for the facts that no maria show any deformations in their central regions—where impact should have taken place—and that their ramparts (as represented by the Alps and Apennine chains in the case of Mare Imbrium) are well below the horizon at the centre of these plains. No destructive seismic effects of the impacts of planetesimals, of masses postulated by Gilbert or Urey, need to be feared any more.

Comets with kinetic energies of the order of 10^{31} ergs are, to be sure, relatively scarce. On the other hand, the number of plains, on the Moon, of the size of Mare Imbrium is again quite small; and the probability that in the past 4,600 million years the Moon may have suffered collisions with comets of requisite masses may even be considerable. Collisions with smaller comets may, in turn, have produced craters of the type of Plato, Archimedes, or Ptolemy, the bottoms of which, rimmed by relatively low ramparts, look strikingly like the surrounding maria. Another crater of this latter category may well be Alphonsus. May, in conclusion, a suggestion be raised that the gas discharge recently observed by Kozyrev to escape from its peak could possibly represent an accidental release of some gas deposited there by cometary impact at a distant time in the past?

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PHYSICS

Dirac's Cosmology and the Dating of Meteorites

It was long ago suggested by Dirac[1] that, from considerations based upon the sizes of the important physical and astrophysical constants, there were reasons for believing that the gravitational constant, when expressed in atomic units, was not a true constant but that it varied inversely with the age of the universe. It has been pointed out that of the other physical constants, only the weak coupling constant would be expected to vary strongly with time, assuming the correctness of the Dirac hypothesis[2].

It is interesting to note that an argument based upon such a fundamental consideration as Mach's principle has also been used for supporting the idea of a varying gravitational constant[3,4] and hence by implication perhaps also the β-decay constant.

In the absence of a clear theory, the only type of argument which would enable a calculation of the rate of change of the β-coupling constant with time is the argument based upon Dirac's hypothesis. If this is correct, one would expect the rate of β-decay to vary with time as t^{-n} with $1/4 < n < 1/2$. The reason for the uncertainty is the rather rough meaning that can be given to the order of magnitude of the large dimensionless numbers[2]. On the other hand, the time-scale is here set by the strong interactions, of which the α-decay is an example. Thus, compared with the ages determined by α-decay, a discrepancy should appear in the ages determined by β-decay. Since reference 2 appeared, there has been a new estimate of the age of the universe[5], based on the Hubble constant, giving a value of about 13×10^9 years. The purpose of this communication is to use this new age to calculate the correspondence between α- and β-decay ages in order to see if the available data on the meteorite ages can be used for excluding the hypothesis of a weak interaction constant varying with time.

If the time-scale determined by α-decay is designated as t and the β-decay time-scale is t_β, then there is the following connexion between the two scales:

$$t_\beta = \frac{1}{1-n}\left[\left(\frac{t}{T}\right)^{1-n} - n\right] T \qquad (1)$$

where $T = 13 \times 10^9$ years is the present age of the universe and the present times and time-rates are adjusted to be equal for the two different time-scales. Note that equation (1) gives:

$$\mathrm{d}t_\beta = \left(\frac{t}{T}\right)^{-n} \mathrm{d}t \qquad (2)$$

in accordance with the above assumption about the variation in the β-decay rate. Equation (1) is set out in Table 1 for times in the past and for two extreme values of n.

Table 1

α-decay age $T - t$	β-decay age $T - t_\beta$	
	$n = \frac{1}{4}$	$n = \frac{1}{2}$
$0 \cdot 0 \times 10^9$ years	$0 \cdot 00 \times 10^9$ years	$0 \cdot 00 \times 10^9$ years
0·5	0·50	0·50
1·0	1·01	1·02
1·5	1·51	1·55
2·0	2·04	2·09
2·5	2·57	2·63
3·0	3·10	3·20
3·5	3·63	3·77
4·0	4·18	4·37
4·5	4·73	4·98

Table 1 should be interpreted in the following way: If a determination of a potassium-40–argon-40 or rubidium-87–strontium-87 age is assumed to be $4 \cdot 73 \times 10^9$ years, then with the assumption that $n = 1/4$, the true age, that is, that given by a lead determination, would be $4 \cdot 50 \times 10^9$ years.

Comparisons between β- and α-decay ages have been made for rubidium-87 and uranium and thorium dates by Aldrich, Wetherill, Tilton and Davis[6]. A similar comparison was made for potassium-40 by Wetherill, Wasserburg, Aldrich, Tilton and Hayden[7]. These comparisons were based largely upon measurements made on rocks with ages less than $2 \cdot 8 \times 10^9$ years. While they seem to be very careful measurements, the expected discrepancy for such ages is at best only 5 per cent. It is very unlikely that these comparisons can be used for excluding the effect in question.

It may be noted that for ages as great as those of the meteorites, $\sim 4{\cdot}5 \times 10^9$ years, there is a more noticeable discrepancy between α- and β-ages. Thus for the case of the meteorites there may be a better chance to confirm or reject the hypothesis of a varying weak interaction constant. Unfortunately, because of the discordance between lead–lead[8] and uranium–lead[9] ages of meteorites, there is reasonable doubt about the accuracy of the ages based on lead ratios. Also, because of the spread in ages obtained from the potassium-40–argon-40 method[10,11], there is reason for believing that some argon has been lost. This throws this determination somewhat in doubt. The strontium-87–rubidium-87 determinations[12] are few and may not have the necessary reliability.

It is concluded that there is no present evidence sufficiently reliable to rule out a variation with time in the β-decay rate.

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The De Haas–Van Alphen Effect in Copper

The de Haas – van Alphen effect in copper has been observed in a whisker made by the Brenner method[1] and oriented with the [111] axis along the field (see Fig. 1); the period is about $1{\cdot}7 \times 10^{-9}$ gauss^{-1}, which is close to the value for a free electron sphere of one electron/atom and not inconsistent with the Fermi surface proposed by Pippard[2]; the effective electron mass as estimated from the temperature variation of the effect is about 1·3 times the free electron mass.

Previous negative results[3,4] may have been due to (*a*) crystal imperfections, (*b*) eddy currents associated with the impulsive field, (*c*) non-occurrence of the effect in certain crystal directions. Copper whiskers are usually very well oriented along one of the principal crystal directions and are of good quality as crystals; thus they are particularly favourable as regards (*a*), since the influence of a given degree of imperfection is least along a direction of symmetry. Moreover, a whisker provides in a natural way a very thin crystal wire and thus helps as regards (*b*); the diameter of the whisker used was about 0·2 mm. It is interesting to note that three other whiskers, two oriented along [100] and one along [110], showed no de Haas – van Alphen effect; this may well be merely because of inadequate sensitivity (in the successful observation the oscillations had only about ten times the noise amplitude), but it is possible that the magneto-resistance effect is particularly high for the [111] direction[5–7] and not for the other directions,

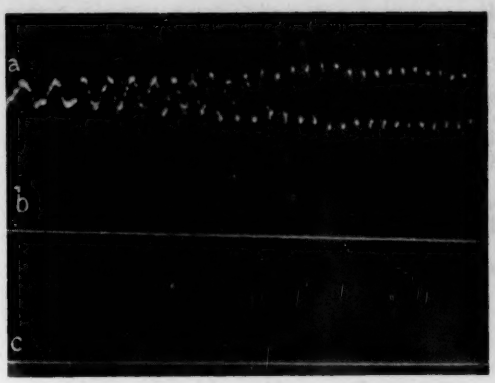

Fig. 1. Trace *a* shows the amplified output from a pick-up coil containing the [111] whisker at 1·1° K. in a magnetic field *H* of about 72,000 gauss, which drops by about 250 gauss across the picture during a time of sweep of about 0·6 msec. This drop is indicated by the slight decrease of separation between traces *b* and *c*, which is a measure of the variation of (*H* − 67,000) gauss. The shortening of the interval occupied by each successive period is due to the increasing rate of decrease of the magnetic field from left to right

thus making the [111] whisker particularly favourable as regards reducing eddy currents.

The discovery of a positive effect in copper removes the suspicion that the earlier negative results in monovalent metals may have been due to fundamental rather than technical reasons, and thus opens the way to a detailed investigation of the electronic structure of these metals.

It is a pleasure to acknowledge the hospitality of the General Electric Research Laboratory, Schenectady, N.Y., during last September, which provided the opportunity of obtaining the whiskers, and I should like particularly to thank Mrs. Ethel Fontanella, of General Electric, for her assistance in preparing the whiskers for use, and Mr. Harry Davies for his assistance in the experiments.

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Crystal Structure of Foshagite ($Ca_4Si_3O_9(OH)_2$)

We have recently made some predictions about the crystal structure of foshagite, based on a study of the dehydration process at 700° C. together with electron diffraction and X-ray fibre evidence[1]. There were strong indications that the structure consists of calcium and hydroxyl ions, and metasilicate chains resembling those in wollastonite[2], and the approximate positions of the calcium ions were suggested. A complete trial structure is now postulated, and more detailed consideration of the X-ray evidence shows that it is essentially correct.

The structure is shown in Fig. 1 with that of para-wollastonite (monoclinic β-monocalcium silicate) for

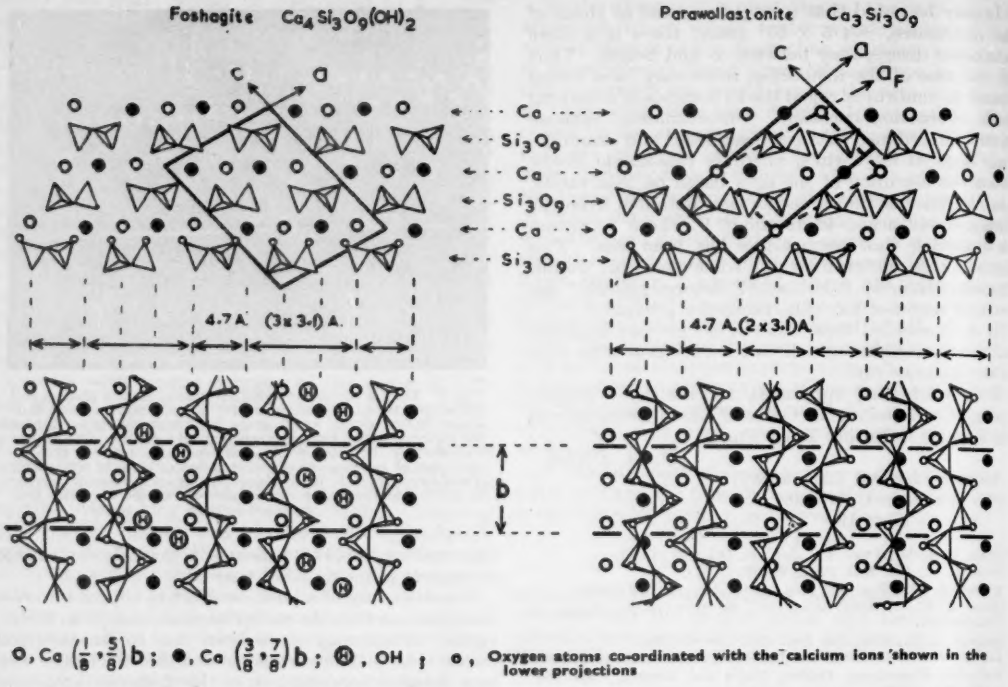

Fig. 1. Projections of the structures of foshagite and parawollastonite. Full lines define unit cells. Broken lines in figure for parawollastonite outline pseudo-cell of foshagite, showing how the calcium positions are related in the two structures

comparison. As previously suggested, the positions of many of the calcium ions, and also those of many of the oxygens, are nearly the same in the two structures, but there are fewer metasilicate chains in foshagite, the excess charge being balanced by hydroxyl. In both cases, the calcium ions lie in distinct planes (201 for parawollastonite and 102 for foshagite). Within these planes, they occur in rows parallel to b, adjacent rows being separated by either 3·1 or 4·7 A. The 3·1 A. separation is the same as the corresponding one in calcium hydroxide, and each metasilicate chain is kinked so that the oxygens on one side can participate in formation of an octahedral Ca—O sheet resembling that in calcium hydroxide (Fig. 2). In foshagite, some of the oxygen positions are occupied by hydroxyl. On the opposite side of each chain, the oxygens are farther apart in projection, causing the octahedral sheets to be split into bands. These are four calcium ions wide in foshagite and three in β-monocalcium silicate,

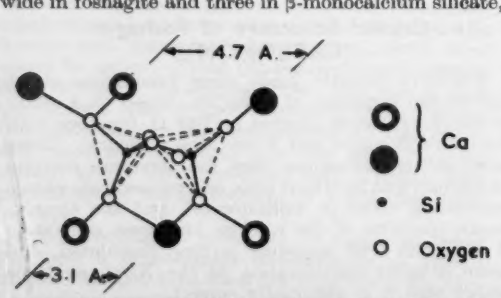

Fig. 2. Projection on (010) of a single metasilicate chain with co-ordinated calcium ions, showing Ca—Ca distances in projection of 3·1 and 4·7 A.

corresponding to the Ca : Si ratios of 4 : 3 and 3 : 3 respectively.

As crystals of foshagite sufficiently large for single-crystal X-ray work are unknown, the structure was tested by comparing calculated structure factors with ones derived from X-ray fibre rotation photographs. The R-factor for the first fifty-eight $h0l$ reflexions was 0·29, and that for the first thirty-six $h2l$ reflexions was also 0·29. In view of the difficulties of measuring the intensities accurately, and also of indexing some of the reflexions, this was considered adequate proof that the structure was basically correct, and refinement will be attempted. No attempt was made to calculate intensities for reflexions with k odd, which are extremely weak and streaked because of mistakes of $b/2$ in the positions of the metasilicate chains.

The unit-cell given previously (a, 10·32; b, 7·36; c, 14·07 A.; β, 106·4°; A-face centred) is confirmed, but it is only geometrically monoclinic, and the true cell is triclinic with half the volume and space-group $P\bar{1}$. Provisional atomic co-ordinates are given (Table 1) in terms of the A-centred cell.

Table 1. Provisional Atomic Co-ordinates for Foshagite

	x	y	z
Ca_I	0·389	0·125, −0·375	0·300
Ca_{II}	0·164	0·375, −0·125	0·398
Si_I	0·306	0·125	0·057
Si_{II}	0·158	0·408, −0·158	0·154
O,OH_I	0·447	0·125, −0·375	0·127
O,OH_{II}	0·306	0·125, −0·375	−0·058
O_{III}	0·234	0·375, −0·125	0·264
O_{IV}	−0·006	0·375, −0·125	0·128
O_V	0·228	0·306, −0·056	0·079
O_{VI}	0·172	−0·375	0·134

The relation of foshagite to β-monocalcium silicate is somewhat analogous to that of members of the chondrodite series to olivine; the two minerals could be regarded as the first two members of a series with general formula $Ca_{2+n}Si_2O_{5+n}(OH)_{2n}$. It is structurally possible that more basic members of this series may exist and hillebrandite ($2CaO.SiO_2.H_2O$) may be the member with $n = 3$; this hypothesis is being investigated. The crystal structure of foshagite was briefly described at the symposium on "Kristallchemie und Strukturanalyse", Berlin, March 1958, and a full account will later be published elsewhere.

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Electron Affinity of Atomic Lithium

Recent measurements[1] of some atomic electron affinities based on observations of the optical threshold for electron detachment give rise to a need for theoretical calculations of electron affinities for comparison. However, none of the empirical extrapolation methods has a justifiable theoretical basis for the extension from atoms and positive ions with attractive Coulomb fields to negative ions with fields of short range. In the case of H^- the extrapolated value[2] of the electron affinity is in good agreement with the value obtained by quantum-mechanical calculations[3], but in the case of Li^- the question still remains unanswered.

Geltman[4] has used the value electron affinity (Li) = 0·384 eV., obtained by a quadratic extrapolation procedure with spectroscopic data on isoelectronic systems, for the threshold in his theoretical calculations of the continuous absorption coefficients of Li^-. This value does not agree with other estimated values (Ta-You Wu[5], 0·90 eV.; Moiseiwitsch[6], 0·74 eV.; and Holøien[7], 0·75 eV.).

The Ritz variational principle is a method frequently used for determining the electron affinity as the difference in potential energy between the ground-state of the atom and the ground-state of the negative ion. The limit to which a given choice of potential parameters makes the energy converge may be used as a criterion for the reliability of the results obtained.

However, such a calculation minimizing the energy in the Ritz variational procedure is difficult and tedious to carry out when applied to the four-electron Li^- ion, but in view of the facts mentioned above, a variational determination of electron affinity (Li) is very important. Fortunately, much progress is made by using an electronic computer in evaluating the matrix elements and solving the secular equation.

The purpose of this communication is to direct attention to results already obtained by variational calculation of the energy of H^- in the $(2s)^2\ ^1S$ state using a 20-parameter function[8]. If we neglect in Li^- the inter-shell interaction and consider the K-shell as essentially at the nucleus, the variational procedure is identical with that for the $(2s)^2\ ^1S$ state of H^-. By using the data quoted in Table 3, ref. 8, for H^-, the electron affinity E (Li→Li⁻) = 0·81 eV. is obtained in good agreement with the estimated results[5-7] (1 eV. = 8066·0 cm.⁻¹). As an interesting comparison the data for helium quoted in the same table give $E(Be^+ \rightarrow Be) = 8{\cdot}12$ eV. (the observed value is 8·89 eV.).

Of course, when taking into account the repulsion of electrons with parallel spin by the penetration of the L-electrons into the charge distribution due to the K-electrons, the above electron affinity will be reduced; but by how much? It is hoped that a variational calculation applied to the ground-state of Li^- by using a 20 × 20 matrix built up from the same configurations for the L-electrons as in ref. 8 will answer this question. Further work along these lines is now in progress.

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Improvement in the Magnetic Detecting Power of Iron-cored Search Coils

Slowly changing magnetic fields have usually been measured by means of search coils with iron or mumetal cores, connected either to fluxmeters or to galvanometers. In this communication the term 'coiled rod' is employed and means a straight ferromagnetic rod about which a detector-coil is wound. The sensitivity or detecting power of the coiled rod is usually defined as the total number of flux linkages of the winding produced in the coiled rod by a spatially uniform magnetic field of one oersted and is measured in Maxwell-turns per oersted. The advantage of mumetal over iron for the core of the coiled rod has been its high permeability in low magnetic fields, low electrical losses and low coercive force. Any further increase in sensitivity of coiled rods has been obtained either by lengthening the rod and so reducing its demagnetizing factor or by winding on more turns—the latter case being accompanied by a rapid increase in inductance and by increased resistance unless the diameter of the wire in the coil is correspondingly increased, which in turn affects the overall diameter.

It has been found that a very useful increase in sensitivity of a given coiled rod can be obtained by fitting permeable collector cones to the ends of the rod, the vertices of the cones facing towards the centre of the rod. So far as the experiments have proceeded, an eight-fold increase in sensitivity may be obtained. The increase in detecting power appears to be almost linear with diameter of cone up to the largest tested (1·5 times the length of the rod), the detecting power being increased by a factor K:

$$K = \left(1 + n\frac{D}{l}\right)$$

where n is about 6 for cone diameters (D) less than half the length (l) of the rod, and 5 for larger cones. A good working approximation for the whole range of D up to 1·5 l (and perhaps beyond) being:

$$K = \left(1 + 5{\cdot}4\frac{D}{l}\right)$$

It also appears that this increase in detecting power is accompanied by only a small increase in inductance, for example, in one case where K (detecting power) equalled 2·10, the corresponding inductance factor K_L was only 1·3. (K_L is defined similarly to K, that is, the ratio of the inductance of the coiled rod with collector cones to the inductance without cones.)

The expression above applies to coiled rods in which a uniform winding covers most (90 per cent) of the length of the rod; smaller increases only would be achieved where concentrated or asymmetric windings are employed, since it is known that fittings to the end of the rod affect the central flux in the rod to a much smaller extent than the flux towards the ends—they cause a more uniform distribution of flux over the whole length of the rod.

Cones have been used on mumetal rods of relatively large size ($\frac{3}{8}$ in. and greater diameters and a wide variety of lengths) and the axial depth of the cone has been arbitrarily fixed at 1 in. in order to provide a suitable fitting to the rod: each end of the rod fits into a recess in the cone and is rigidly secured by a steel screw. A typical design is illustrated in Fig. 1, in which the left-hand cone is shown withdrawn from the drilled and threaded rod-end. The material for the cones found most satisfactory has been machined mild steel, but cast steel has been successfully used in one case. Solid cones in the larger sizes cause a significant increase in the weight of the assembly; but hollow cones in various forms have been found to be useless as intensifiers. No investigation has been made on miniature coiled rods, where rod diameters may be $\frac{1}{4}$ in. downwards to small-wire or rolled-strip sizes, to determine the corresponding practical axial depth of the cone for satisfactory use with such small detectors.

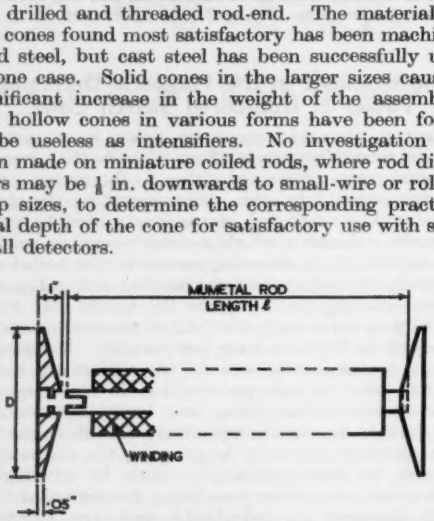

Fig. 1. Typical arrangement of mild steel collector cones on a coiled rod

Collector cones may be most useful where axial length of the coiled rod is restricted; where the weight, cost or resistance of the copper coils must be kept down but where the overall diameter is less important; or where cones of a diameter equal to or exceeding the length of rod may be employed. Where alternating magnetic fields are to be measured, precautions will have to be taken against losses due to eddy-currents in the cone as well as in the material of the rod. It would be interesting to investigate whether cones, in a suitable permeable material of high specific resistance, could be used with similar success in fluxgate detectors as intensifiers, since it is expected that an improvement in output signal voltage may be obtained similar to that described above for induction systems.

The mechanism of the increase is not fully understood. Since the distribution of flux along the rod is more uniform when cones are fitted, it may be deduced that the effect is caused by the spreading of the demagnetizing poles outwards from the ends of the rod on to the outside face of the cones. There is some evidence, however, that the magnetic field in part of the annular space between the cones but outside the rod (that is, the space occupied by the copper coils) is higher than the external field to be measured. This suggests that part of the function of the cones is to enhance the external field between them.

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Effect of Humidity on the Spark Breakdown Voltage

The influence of water vapour on the breakdown voltage of uniform field gaps has been investigated by Ritz[1]. He found that the breakdown voltage of a 1-cm. uniform field gap at 760 mm. mercury pressure in air increased by 2 per cent for a change in the partial pressure of water vapour from 10 to 25 mm. mercury. More recently, Köhrmann[2] has published results which indicate that the presence of water vapour at 10 mm. mercury raised the breakdown voltage by 2·7 per cent above that of dry air at 760 mm. mercury. Lewis[3] investigated the humidity effect for sphere gaps and quoted an increase of 0·13 per cent in voltage for each mm. mercury of water vapour. This value is rather low compared with the two other results and may be due to the fact that he used a gap of 0·4 cm. between 2-cm. spheres.

A uniform field gap was mounted within a glass cylinder which could be evacuated and gases admitted through a drying system. Water vapour could be added and its partial pressure measured. The d.c.-voltage source was stabilized to better than 1 part in 5,000 per hour. The breakdown voltage was determined by plotting the sparking-rate for a range of voltages above the minimum value and extrapolating the curve to a voltage corresponding to zero sparks per minute. The spark gap was unirradiated since it had been found that irradiation reduced the breakdown voltage of a plane gap by only about 0·1 per cent.

Measurements have been made under the following conditions: (1) plane electrodes, with a Bruce profile, in air at pressures of 760 mm. and 500 mm. mercury with water vapour and for gaps of 1 cm. and 2 cm. respectively; (2) plane electrodes in nitrogen at 760 mm. mercury with a mixture of 2 : 1 ethyl alcohol – water vapour and a 1-cm. gap; (3) spheres of 2-cm. diameter in air at 760 mm. mercury with water vapour and a 1-cm. gap.

The effect of humidity on the breakdown voltage in air and nitrogen is plotted in Fig. 1. The values for 2-cm. spheres appear to fit the same curve as those for plane electrodes. Two points are plotted which were obtained in moist laboratory air. These points also fit the curve reasonably well. Also shown in Fig. 1 are the results for the effect of ethyl alcohol – water vapour on the breakdown in nitrogen. These points lie below the curve for water and air; this is to be expected if the increase in voltage is solely an effect due to the water, since the partial pressure of water in the vapour mixture was 36 per cent of the total pressure of the vapour mixture. The breakdown

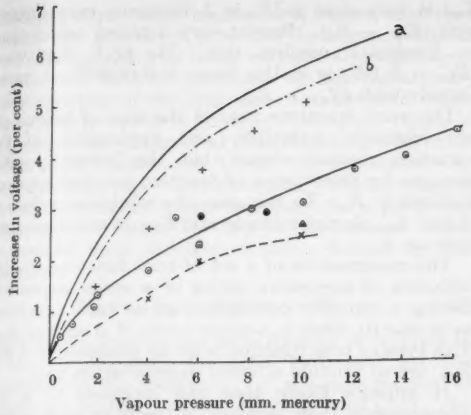

Fig. 1. Effect of vapour on breakdown voltage. (*a*) After Köhrmann (ref. 2) for 2-cm. gap at pressure of 500 mm. mercury; (*b*) calculated from measurements for a 1-cm. gap at 760 mm. mercury; +, air and water vapour, 2-cm. gap between plane electrodes at 500 mm. mercury; ⊙, air and water vapour, plane electrodes, 760 mm. mercury; ●, moist atmospheric air, plane electrodes, 760 mm. mercury; ⊡, air and water vapour, 1-cm. gap between spheres at 760 mm. mercury; △, after Köhrmann (ref. 2), plane electrodes at 760 mm. mercury; ×, nitrogen and ethyl alcohol–water vapour, plane electrodes at 760 mm. mercury

voltage in dry nitrogen was found to be 2·6 per cent higher than in air at 760 mm. mercury and 20° C. This difference could be explained by the lower value of α/p for nitrogen.

Referring to the results of Köhrmann for a 2-cm. gap in air at 500 mm. mercury it was noted that the effect of humidity was greater than for a 1-cm. gap at a pressure of 760 mm. mercury. These results are plotted in Fig. 1. Measurements made by us for a 2-cm. gap at 500 mm. mercury lie slightly below those of Köhrmann. The chain dotted line in Fig. 1 gives the values obtained at 760 mm. mercury for a 1-cm. gap normalized to 500 mm. mercury.

It was found that the rate of sparking was also a function of humidity. Several examples are plotted as histograms in Fig. 2 for increasing amounts of ethyl alcohol – water vapour in nitrogen. The rate of sparking for dry nitrogen increased from zero to 48 sparks/min. for a change in voltage of 0·13 kV., whereas with 10 mm. mercury vapour pressure the rate of sparking increased from zero to 25 sparks/min. for a change in voltage of 0·34 kV. When the vapour pressure was 14 mm. mercury the rate of sparking was approximately the same but the threshold voltage for sparking fell to a lower value. This threshold shifted to a higher voltage with continued sparking as shown in Fig. 2(*d*). Histogram (1) shows the first rate of sparking; after 20 min. sparking the histogram (2) shifted to a higher voltage and after 40 min. reached the still higher voltage of histogram (3). It was concluded that when the vapour pressure reached a certain value, condensation occurred on the electrodes and lowered the breakdown voltage. This layer of liquid was removed by sparking and the breakdown voltage then increased. Measurements with spheres showed a rather flat histogram for the rate of sparking, similar to Fig. 2(*d*), and accurate determination of the minimum breakdown voltage was more difficult.

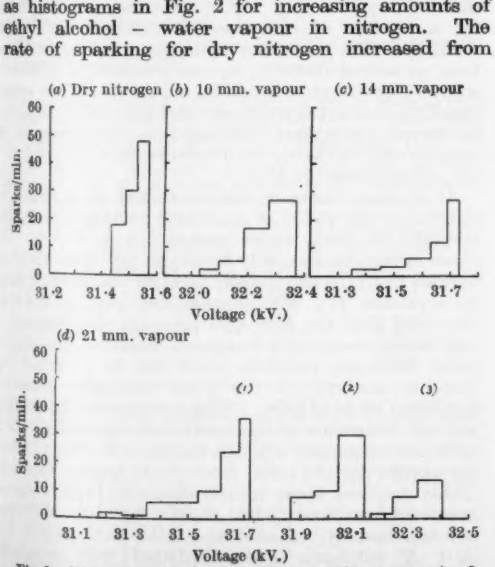

Fig. 2. Histograms of rate of sparking for different amounts of vapour.

It may be concluded that the effect of water vapour is to increase the breakdown voltage by 3·5 per cent for 10 mm. mercury partial pressure of water vapour at 760 mm. mercury. The results are in general agreement with those of Köhrmann and Ritz for plane electrodes at 760 mm. mercury pressure in air. It is obviously necessary to correct for humidity when comparing values of breakdown voltage obtained under different conditions.

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CHEMISTRY and GEOCHEMISTRY

Use of Approximate Wave Functions for Extrapolation to True Energy Values

A WAVE equation $H\varphi = E\varphi$ can be written for any trial function φ. Only if φ is equal to an eigenfunction ψ_n, however, does E have a constant value (E_n). In general, for any trial function, φ, there is a corresponding average energy, $E_{av.}$, defined by:

$$E_{av.} = \int \varphi^* H \varphi \, d\tau / \int \varphi^* \varphi \, d\tau$$

The variation principle shows that for the lowest state $E_{av.} \geqslant E_0$, and $E_{av.}$ is thus an upper bound to the true energy, E_0. No means is provided by the variation principle for the extrapolation to E_0 from a series of calculated values of $E_{av.}$

For an approximate function φ, the function $E = H\varphi/\varphi$ fluctuates about the mean value $E_{av.}$ with mean square deviation Δ given by:

$$\int \varphi^* \left(\frac{H\varphi}{\varphi} - E_{av.} \right)^2 \varphi \, d\tau \geqslant 0$$

Δ becomes equal to zero only when $E_{av.} = E_n$, a true eigenvalue. From a graph of Δ against $E_{av.}$, it might be possible to extrapolate back to $\Delta = 0$, where $E_{av.} = E_n$, and thus provide a useful means of estimating eigenvalues.

Calculations are presented here for two simple systems: (1) a single electron constrained to move in a ring in which the potential energy is a simple one-step function; (2) the helium atom in its ground-state.

(1) *Particle in a ring.* The ground-state eigenfunction is known in this case, and for the two regions of constant potential has the form:

$$a.\ \cos m\theta \left(-\frac{\pi}{6}<\theta<\frac{\pi}{6},\ V=0\right),$$

$$b.\ \cosh m'\theta\left(\frac{\pi}{6}<\theta<\frac{11\pi}{6},\ V=V_0\right)$$

θ being the cyclic co-ordinate. Successive approximations φ_n to the eigenfunction ψ_0 were obtained by taking inclusively the first n terms of the Fourier (cosine) series expansion of ψ_0. The corresponding values of Δ and $E_{av.}$ were readily calculated and are plotted together in Fig. 1.

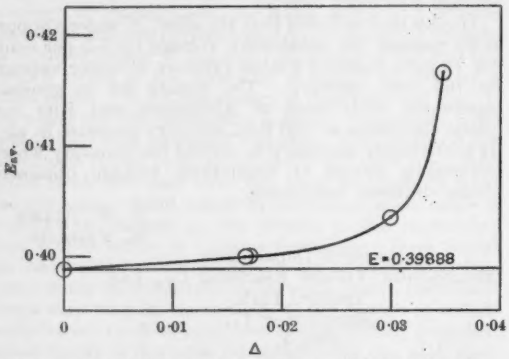

Fig. 1. Graph of $E_{av.}$ against Δ for a particle in a ring; the successive points are for 1-, 2-, 3- and 4-term Fourier (cosine) series. (Arbitrary units)

(2) *Ground-state helium atom.* The true ground-state energy is known spectroscopically. Approximate wave functions of the form (i) $\varphi = u(1)u(2)$, where $u(1)$ represents a hydrogen-like 1*s* function, and (ii) $\varphi = u_1(1)u_2(2) + u_1(2)u_2(1)$, were employed. The effective nuclear charges Z_1 and Z_2 were used as parameters in the usual way and the corresponding values of Δ and $E_{av.}$ calculated. These values are plotted together in Fig. 2.

The general form of the plots of Δ against $E_{av.}$ is similar in the two cases. Apparently, only when

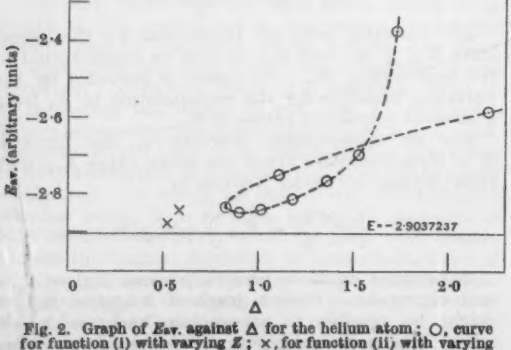

Fig. 2. Graph of $E_{av.}$ against Δ for the helium atom; ○, curve for function (i) with varying Z; ×, for function (ii) with varying Z_1 and Z_2

$E_{av.}$ is very close to E_0 is Δ likely to vary linearly with $(E_{av.} - E_0)$. Recent very detailed calculations by Kinoshita[1] confirm this. He finds that when $(E_{av.} - E_0)/E_0$ is in the range 0–0·000007, Δ varies linearly with $(E_{av.} - E_0)$.

The wave functions used in the case of helium (ii) are relatively inflexible, and application of the variation method shows that the lowest possible energies for these types of function are bad approximations to E_0. In this case the minimum values of Δ and $E_{av.}$ do not coincide and $E_{av.}$ is not dependent only on Δ.

The construction of a set of trial functions by the inclusion of successive terms of a series expansion, having a complete orthogonal set as basis functions, as in case (i), leads to a single curve of Δ against $E_{av.}$. This type of trial function is to be preferred if Δ and $E_{av.}$ are to provide a useful extrapolation pair.

It appears likely that the inclusion of a not unreasonably large number of terms in such a trial function can enable a fair extrapolation to E_0 to be made.

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Determination of the Yields of Molecular Hydrogen Peroxide in the Radiolysis of Water labelled with Oxygen-18

The decomposition of water by the action of ionizing radiations can be represented by the overall expression[1,2]

$$H_2O \text{ —}\sim\!\!\sim\!\!\rightarrow H,\ OH,\ H_2,\ H_2O_2 \qquad (1)$$

The relative extents of the radical (H, OH) and molecular yields (H_2, H_2O_2) have been determined for a number of radiations of different ionization densities. The molecular hydrogen yield ($G^{W}_{H_2}$) has been measured directly, in the presence of different solutes (for example, bromide, nitrite[3]). On the other hand, the molecular hydrogen peroxide yield ($G^{W}_{H_2O_2}$) in aqueous solutions irradiated in the presence of oxygen can ordinarily be measured only indirectly[4,5]. (G = molecules/100 eV.)

It is clear, however, that it should be possible to determine tl e yields of molecular hydrogen peroxide directly by using water enriched with $H_2{}^{18}O$. In these circumstances, only hydrogen peroxide which is formed from the isotopically labelled water, according to equation (1), will contain the oxygen isotope. Provided that the hydrogen peroxide thus formed is not decomposed by subsequent reactions, the molecular hydrogen peroxide yield can be obtained by isotopic analysis of the total hydrogen peroxide produced on irradiation. This analysis can be carried out by treatment of the irradiated aqueous solution with permanganate, which is known to liberate molecular oxygen derived solely from the hydrogen peroxide. Table 1 shows some results obtained from aqueous solutions enriched with $H_2{}^{18}O$ for two different solutes, namely, ethanol and lactic acid at *p*H 1·2 (0·1 *N* sulphuric acid) irradiated with cobalt-60 γ-rays and with 200 kV. X-rays. These two particu-

lar solutes were chosen because it is known that they protect the primarily produced hydrogen peroxide from decomposition by being very effective scavengers for the free radicals produced by the radiation[6,7]. The proportion of the hydrogen peroxide yield which comes from the water is given by: $G^{w}_{H_2O_2} = G_{H_2O_2} \times M_R$, where $G_{H_2O_2}$ is the total yield of hydrogen peroxide produced by radiation. Under the conditions employed in these experiments the total yield of hydrogen peroxide $G_{H_2O_2}$ has a constant value for a particular radiation (see Table 1). M_R is the isotopic ratio, determined mass spectrometrically, defined by the equation:

$$M_R = (N_x - N_i)/(N_e - N_i) \qquad (2)$$

where N_x represents the mole fraction of oxygen-18 in the oxygen from the total hydrogen peroxide (produced by the radiation); N_i the mole fraction of oxygen-18 in the cylinder oxygen used; N_e the mole fraction of $H_2{}^{18}O$ in the enriched water used as solvent (usually of the order of 1·5 mole per cent). It can be seen from Table 1 that the yield of molecular hydrogen peroxide depends upon the solute concentration; by plotting the observed yield against the cube root of the solute concentration, it has been found that there is a linear relationship over the concentration range of 10^{-4} to 10^{-2} M. A similar situation has also been observed in the irradiation of bromide solutions saturated with air[4,5]. This dependence on the cube root of the solute concentration can be related to the reaction between the precursor of the molecular hydrogen peroxide with the solute molecules. If one has a diffusion-controlled reaction, one can show (for the case of spherical symmetry) that the probability that the precursor has escaped from a reaction with the solute molecules is proportional to $(1 - r_0/r_i)$, where r_0 is the distance at which the reaction occurs and r_i is the initial distance between the precursor and the solute molecules. This latter distance is proportional to the mean distance between the solute molecules, which, at random distribution of the solute molecules, is proportional to $c^{-1/3}$ (where c is the concentration of the solute).

Thus $G \propto (1 - \varkappa r_0 c^{1/3})$, which is the experimentally observed relationship ($\varkappa$ = constant).

Table 1. Molecular Hydrogen Peroxide Yields ($G^{w}_{H_2O_2}$) from Dilute Aqueous Solutions of Ethanol and of Lactic Acid irradiated with X-rays and with γ-rays in the Presence of Oxygen (1 atm.) at pH = 1·2 (0·1 N Sulphuric Acid)

X-rays (200 kV.): dose-rate = $8·0 \times 10^{-7}$ eV./N ml.$^{-1}$ min.$^{-1}$ (for $G_{Fe^{3+}} = 15·0$ in 10^{-3} M ferrous sulphate in 0·1 sulphuric acid); total (constant) hydrogen peroxide yield: $G_{H_2O_2} = 4·0$

	Solute concentration (M) c	Isotope ratio M_R	Molecular hydrogen peroxide yield $G^{w}_{H_2O_2}$
Lactic acid	$1·0 \times 10^{-1}$	0·198	0·790
Lactic acid	$3·5 \times 10^{-2}$	0·203	0·808
Lactic acid	$1·0 \times 10^{-2}$	0·225	0·895
Lactic acid	$2·0 \times 10^{-2}$	0·238	0·949
Lactic acid	$4·2 \times 10^{-4}$	0·250	0·997
Ethanol	$1·0 \times 10^{-2}$	0·221	0·880

γ-Rays (cobalt-60): dose-rate = $3·5 \times 10^{-7}$ eV./N ml.$^{-1}$ min.$^{-1}$ (for $G_{Fe^{3+}} = 15·5$ in 10^{-3} M ferrous sulphate in 0·8 N sulphuric acid); total (constant) hydrogen peroxide yield: $G_{H_2O_2} = 3·54$

	c	M_R	$G^{w}_{H_2O_2}$
Lactic acid	$1·0 \times 10^{-2}$	0·179	0·635
Ethanol	$1·0 \times 10^{-1}$	0·145	0·514
Ethanol	$3·4 \times 10^{-2}$	0·153	0·542
Ethanol	$1·0 \times 10^{-2}$	0·181	0·641
Ethanol	$3·4 \times 10^{-3}$	0·183	0·648
Ethanol	$1·0 \times 10^{-3}$	0·193	0·684

Hence, it appears that increasing the solute concentration leads to an increase in the extent of scavenging of the precursor of the molecular hydrogen peroxide. It is of interest to note that, with both ethanol and lactic acid solutions, very similar values for $G^{w}_{H_2O_2}$ were obtained when irradiated under the same conditions. The experimental results, after extrapolation to zero solute concentration, give the following values:

for X-rays (200 kV.), at pH 1·2: $G^{w}_{H_2O_2} = 1·05 \pm 0·02$

for γ-rays, at pH 1·2: $G^{w}_{H_2O_2} = 0·73 \pm 0·03$

From work on bromide solutions Sworski[4] has deduced, by an indirect method, a value of $G^{w}_{H_2O_2} = 0·75$ from irradiations with γ-rays at pH 2·0 and a value of 0·78 in 0·8 N sulphuric acid.

There is a significant increase in the molecular yields on going from γ-rays to 200 kV. X-rays. This may be regarded as a consequence of the different ionization densities of these two radiations. The value for 200-kV. X-rays obtained in the above experiments at pH 1·2 is in good agreement with the value of $G^{w}_{H_2O_2} = 1·09 \pm 0·05$ (corrected for $G_{Fe^{3+}} = 15·0$) which has been obtained from studies of the effects of 200-kV. X-rays on ceric sulphate solutions at the same pH[8].

Some experiments have been carried out with solutions of potassium bromide enriched with $H_2{}^{18}O$ at pH 1·2, and also with pure (enriched) water. Rather low values for the yields of the hydrogen peroxide labelled with oxygen-18 were obtained in these systems. For oxygenated bromide solutions, with γ-rays, a value of approximately 0·3 was obtained, apparently independent of the concentration of the bromide (10^{-4} to 10^{-2} M). In pure water, saturated with oxygen, the G-values of hydrogen peroxide measured by this technique were also low: $G \sim 0·35$ for γ-rays and $G \sim 0·65$ for X-rays (200 kV.). These relatively low values can be attributed to the attack on the hydrogen peroxide by OH radicals according to: $H_2O_2 + OH \rightarrow H_2O + HO_2$ and, in solutions containing bromide, a corresponding attack by bromine atoms which are formed by the OH radicals according to: $Br^- + OH \rightarrow Br + OH^-$.

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A New Iodine Compound : $I{-}OH_2$

When the *p*H of an I_3^- solution, approximately one-tenth molar in iodide, is raised to about 12, part of the I_3^- initially present disappears immediately, and the remainder decomposes slowly, at a measurable rate, due to production of iodate (Fig. 1).

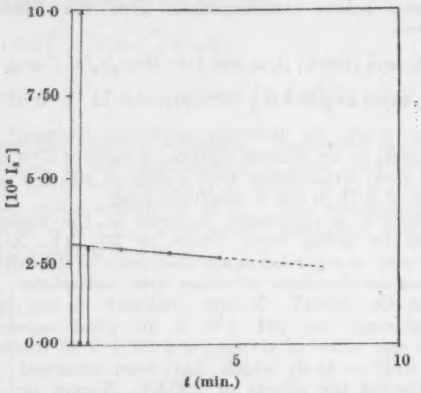

Fig. 1. Disappearance of I_3^- with time. Long arrow, initial iodine concentration; short arrow, initial I_3^- concentration. $[I^-]$, $2{\cdot}00 \times 10^{-1}$ *M*; $[H^+]$, $5{\cdot}35 \times 10^{-13}$ *M*

We have studied quantitatively the instantaneous consumption of I_3^-, the light absorption of this substance, determined[1] at 350 mμ after alkalinization, being extrapolated to zero time. The study was performed in the concentration ranges $8 \times 10^{-3} < [I^-] < 6 \times 10^{-1}$, $1 \times 10^{-13} < [H^+] < 2{\cdot}5 \times 10^{-12}$ and $5 \times 10^{-5} < [\text{initial iodine}] < 5 \times 10^{-4}$ (ionic strength, 0·60; temperature, 25·0° C.), in such conditions that the concentrations of I_2, IOH and I^+ may be neglected. Results have shown that the total effect is linked with the occurrence of two reactions, one producing IO^-, the other the new compound I_2OH^-:

$$I_3^- + H_2O \rightleftharpoons IO^- + 2I^- + 2H^+ \quad k = 2{\cdot}05 \times 10^{-26}$$

$$I_3^- + H_2O \rightleftharpoons I_2OH^- + I^- + H^+ \quad k = 6{\cdot}3 \times 10^{-14}$$

In the past, the determination of equilibrium constants of reactions involving IO^- [2,3] and IOH [1,4,5] has often led to contradictory values. Taking the presence of I_2OH^- in these systems into account explains this anomalous behaviour, and removes the contradictions.

The relative amounts of I_2OH^- and IOH depend only on the concentration of iodide :

$$\frac{[I_2OH^-]}{[IOH]} = 1{\cdot}0 \times 10^3[I^-]$$

The I_2OH^- concentration consequently exceeds that of hypoiodous acid when $[I^-] > 10^{-3}$.

I_2OH^- may be considered as similar to I_3Cl^-, I_3Br^- and I_3^-. It seems probable that it is involved in the mechanism of iodine reactions.

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Hydrated Glasses

It has been found that in silicate and aluminosilicate glasses the vitreous network of linked groups of tetrahedrally arranged oxygen atoms responds to differences of composition by dilation or by contraction[1,2]. This effect is of especial interest in the case of natural glasses, where the water content varies greatly.

Data relating to 132 such glasses have been studied, including 82 of acid composition. Of the latter, 40 rhyolitic and rhyo-dacitic obsidians constitute a well-defined group in which the water content averages about 0·3 per cent by weight, reaching a maximum of 1 per cent. Consideration of the various structural alternatives in the light of the observed physical properties and thermal behaviour suggests that the water is present in these rocks in the form of hydroxyl ions combined as randomly distributed single $SiO_3(OH)$ or $AlO_3(OH)$ groups. This water was acquired while the material was molten, and the proposed structure reflects the low-pressure environment in which cooling occurred.

The remaining 42 acid glasses include intrusive and extrusive pitchstones, a fused grit, a fused granodiorite, perlites and glasses separated from the mesostasis of tholeiitic rocks. Their water content ranges from 2 to nearly 10 per cent. The specific gravity data show that the number of glass-forming ions in unit volume is subject to a linear decrease as the water content increases, the total oxygen content of that volume remaining comparatively constant. As compared with the obsidians, the oxygen is packed more tightly to the extent of about 4 per cent. It is postulated that the structural factor responsible for the closer oxygen packing is five-fold co-ordination of the aluminium. Six-fold co-ordination seems to be precluded.

The glasses of this second group are diverse as to origin and history. Certain of them congealed from a hydrous melt. Under the moderately high pressures attending the intrusion of such a melt into upper crustal rocks, it is believed that groupings such as $AlO_4(OH)$ are formed. The association of the hydroxyl with the AlO_4 group is a passive one, the (OH) forming part of an adjacent tetrahedral cluster.

The structures of acid glasses hydrated after solidification also involve a similar passive co-operation in some instances. Two general types of mechanism are envisaged :

(*a*) At low temperatures, water penetrates into the expansible three-dimensional network, being held by long hydrogen bonds or in zeolite fashion. Dissociation of water molecules is associated with the rupture of bonds between glass-forming or other cations and oxygen with the production of contiguous hydroxyl pairs. Minor positional adjustments ensue, raising the effective co-ordination number of aluminium. The resultant shrinkage generates stress that may aid the propagation of the reaction and lead to the eventual development of perlitic cracking. This mechanical feature is thus developed only in glasses originally possessing 4-co-ordinated aluminium.

(*b*) At higher sub-magmatic temperatures, water dissociates upon entry, and a process that may be described as reconstructive cross-linkage brings into being pairs of hydroxyl ions, the individual ions of each pair being near each other but not in contact. Again, the aluminium assumes a five-fold co-ordination.

In quartzo-feldspathic compositions the (anhydrous) oxygen/glass-former ratio of 2·0 prohibits certain configurations requiring a higher proportion of oxygen. This constraint is lacking in the case of glasses of basic composition, and for them a wide range of structural alternatives is open, subject to control by the ruling physical conditions.

In substantially anhydrous glassy lavas of calc–alkaline type there is a progressive diminution in the number of glass-forming ions in unit volume with change in composition from dacite to basalt. The hydrated rocks corresponding in composition, but of intrusive origin, show oxygen-packing figures which exceed those of the anhydrous types by an amount that increases with the basicity. This effect (which may exceed 7 per cent) is attributed to the variable co-ordination state of aluminium and ferric iron, and reflects the effect of pressure as well as that of hydration. In any hydrated glass the water will be distributed between the different types of possible configuration in a manner reflecting the history of the glass. Several lines of evidence appear to point to a general tendency for the proportion of loosely bound water to increase with the total water content. Thus, for example, application of the Gladstone and Dale relationship shows an increase in the specific refractivity of water related to the rise in its concentration in the glass.

A full account of this work will be published elsewhere.

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BIOCHEMISTRY and PHYSIOLOGY

Possible Role of Water in Collagen Structure

Although several investigations of the infra-red spectrum of collagen in the 2μ region have been reported[1], no comment appears to have been made on the fact that the absorption band at 5,150 cm.$^{-1}$, generally attributed to sorbed water, is dichroic. The extent of this dichroism is shown in Fig. 1 (above), obtained from kangaroo tail tendon in equilibrium with the laboratory atmosphere. In a further spectrum obtained after drying at 100° C. for 3 hr., shown in Fig. 1 (below), the absorption band at 5,150 cm.$^{-1}$ is virtually eliminated, thus confirming its assignment to sorbed water. Subsequent exposure to the laboratory atmosphere restored the dichroic absorption band at 5,150 cm.$^{-1}$.

It is possible that the observed dichroism is spurious in the sense that it is due to form dichroism rather than intrinsic dichroism; but this is unlikely since other fibres such as nylon and silk show no maxima in dichroism at this frequency and α-keratin and feather keratin only very minor maxima. If, as seems to be the case, the dichroism is intrinsic, it follows that hydrated collagen contains a proportion of water molecules which are preferentially oriented with respect to the polypeptide chains.

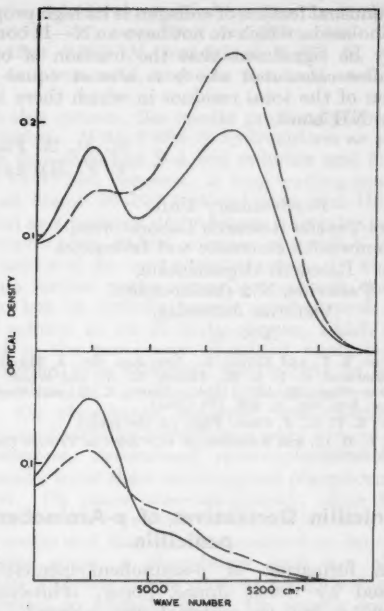

Fig. 1. Infra-red spectra of kangaroo tail tendon. Above, in equilibrium with the laboratory atmosphere; below, dried *in vacuo* at 100° C. for 3 hr. Full line, electric vector vibrating parallel to the tendon axis; broken line, electric vector vibrating perpendicular to the tendon axis

The absorption band at 5,150 cm.$^{-1}$ may be assigned to a combination of the antisymmetrical stretching and symmetrical deformation modes of the water molecule so that the associated transition moment is parallel to the line joining the two hydrogen atoms. The preferred orientation indicated by the perpendicular dichroism is therefore as shown in Fig. 2. From the magnitude of the dichroic ratio it is possible to estimate the minimum fraction of preferentially oriented water molecules[2], and this is found to be 0·18 for the spectrum of Fig. 1 (above).

The configuration of the polypeptide chain in collagen is believed to be such that the CO linkages are approximately normal to the chain axis and that a high proportion project outwards from the triple chain molecule and so are not available for intramolecular hydrogen bonding[3]. It is possible, therefore, that the oriented water molecules are linked to these groups through hydrogen bonds as shown schematically in Fig. 2.

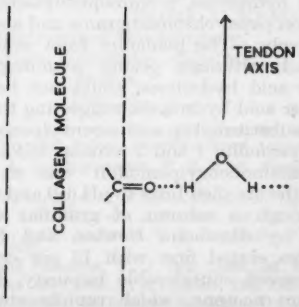

Fig. 2. Preferred orientation for water molecules in tendon deduced from the dichroism of the 5,150-cm.$^{-1}$ absorption band

An unusual feature of collagen is its high proportion of imino-acids, which do not have an N—H bond, and it may be significant that the fraction of oriented molecules calculated above is almost equal to the fraction of the total residues in which there is a CO but no NH bond.

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Penicillin Derivatives of *p*-Aminobenzylpenicillin

The formation of *p*-aminobenzylpenicillin was reported by Corse, Jones, Soper, Whitehead and Behrens[1]; but no material was isolated. Brewer and Johnson[2] later obtained partially purified material by using *p*-aminophenylacetic acid as precursor; but no details of yields or purity were given. The work reported here was carried out in order to obtain *p*-aminobenzylpenicillin for use as the parent compound of a series of derivatives. Tosoni, Glass and Goldsmith[3] have since reported the preparation of crystalline *p*-aminobenzylpenicillin by hydrogenation of *p*-nitrobenzylpenicillin and the preparation of certain N-acyl derivatives.

Fermentations were carried out using *Penicillium chrysogenum* 5120c (a sub-strain selected from 5120 *Wis*) and a peanut meal/lactose medium. *p*-Aminophenylacetamide was added at the rate of 0·05 per cent every 24 hr. Titres at 96 hr. were 1,000–1,200 μ/ml. by cup-plate assay. Paper chromatography using as solvent the top layer of the mixture butanol–ethanol–water, 40 : 10 : 50, indicated the formation of two principal penicillins and smaller amounts of two others as a result of the addition of the precursor (Fig. 1). The two principal penicillins (zones 3 and 4) were eluted from paper chromatograms and zone 3 identified as *p*-aminobenzylpenicillin. This penicillin was shown to contain a primary aromatic amino-group by diazotization and coupling with resorcinol. After acid hydrolysis, *p*-aminophenylacetic acid was identified on paper chromatograms and also estimated quantitatively. The penicillin from zone 4, on the other hand, although giving *p*-aminophenylacetic acid after acid hydrolysis, could not be diazotized except after acid hydrolysis, suggesting this penicillin to be a substituted *p*-aminobenzylpenicillin. The nature of penicillin 1 and 2 remains unknown.

The *p*-aminobenzylpenicillin was extracted by adjusting the clarified brew to *p*H 6·0 and then percolating through a column of granular charcoal as described by Abraham, Newton and Hale[4]. The column was eluted first with 15 per cent acetone, which removed considerable impurity, followed by 60 per cent acetone, which rapidly eluted all the penicillins. The fraction of this eluate containing penicillin was concentrated to small volume *in vacuo*

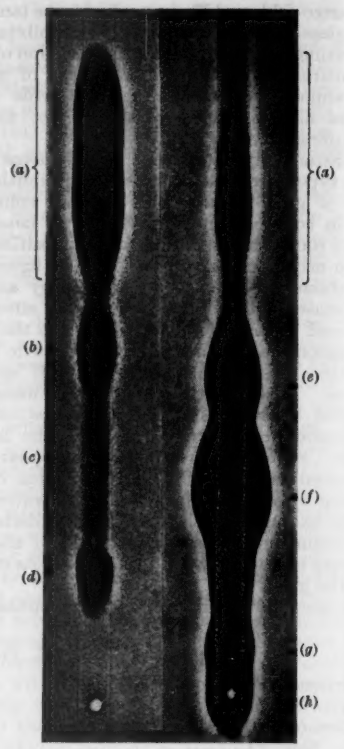

Fig. 1. Paper chromatography of harvest fermentation brew. *A*, No precursor added; *B*, *p*-aminophenylacetamide added, 0·05 per cent every 24 hr. Solvent, butanol–ethanol–water, 40 : 10 : 50, top layer. Chromatograms developed on agar plate seeded with *B. subtilis*. *a*, Penicillins *K*, *FH*$_1$, *F*, *G*; *b*, penicillin *X*; *c* and *d*, unidentified penicillin; *e*, penicillin 4; *f*, penicillin 3; *g*, penicillin 2; *h*, penicillin 1.

and 9 vol. of acetone added to precipitate impurities. The supernatant, after centrifuging, was evaporated *in vacuo* to near dryness. This material was then dissolved in the butanol–ethanol–water chromatography solvent described above and chromatographed down a column of powdered cellulose and developed with the same solvent. The penicillins were eluted separately in the order in which they ran on paper strip chromatograms. The eluate fractions containing the *p*-aminobenzylpenicillin were combined and extracted with water, which was then freeze dried. The pale yellow solid obtained assayed at 800 μ/mgm. by cup-plate assay using benzylpenicillin as standard; pure *p*-aminobenzylpenicillin obtained by Tosoni *et al.*[3] assayed at 1,100 μ/ml., indicating the material described here to have been 73 per cent pure. Assay of the latter material by the hydroxylamine method[5] gave a figure of 75 per cent purity.

During the course of the extraction a white crystalline solid separated out on cooling, which, after recrystallization, was identified as the monohydrate of *p*-acetamidophenylacetamide (by elementary analysis and mixed m.p. with an authentic specimen prepared by acetylation of *p*-aminophenylacetamide). The formation of this material during the fermentation suggested that penicillin 4, which appeared to be a substituted *p*-aminobenzylpenicillin, might be *p*-acetamidobenzylpenicillin. Comparison of this penicillin 4 with an authentic preparation of *p*-acet-

amidobenzylpenicillin prepared from the *p*-aminobenzylpenicillin showed them to be indistinguishable on paper chromatograms and in respect of their antibacterial spectra.

The *p*-aminobenzylpenicillin has been converted into a series of N-derivatives[6] by treatment with reactive halogen compounds such as carboxylic acid halides, 2 : 4-dinitrofluorobenzene and *p*-toluenesulphonyl chloride, following the method of Newton and Abraham[7] for the preparation of derivatives of cephalosporin N. It is hoped to publish further details of these experiments, together with the results of the antibacterial activity of the derivatives, elsewhere, at a later date.

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Nucleotide Metabolism in Cardiac Activity

In a previous study on the nucleotide metabolism of cardiac muscle[1], the changes of adenosine triphosphate were investigated during systole and diastole. Using the Cohn and Carter method of analysis[2] on a 'Dowex-1' column, the nucleotides were separated and determined quantitatively by ultra-violet absorption spectrophotometry. During the studies on the extracts of hearts frozen in systole by an acetone–dry ice mixture, a substance appeared as a new peak in the chromatogram, which seemed to be an adenine nucleotide with more nitrogens than could be accounted for. This was called nucleotide *H*.

In spite of the recent results obtained by Mommaerts[3] and Fleckenstein *et al.*[4] it was decided to re-investigate this problem, with special emphasis on nucleotide *H*.

Hearts of dogs were excised rapidly and dropped either into cold isotonic potassium chloride to stop them in diastole, or into liquid air to freeze them in systole. The hearts were then rapidly homogenized in a Waring blendor with 2·5 vol. 0·5 *N* perchloric acid, centrifuged, and the supernate neutralized to pH 8 with potassium hydroxide. In all these steps, the temperature was kept below 5° C. After removing the potassium perchlorate by filtration, an aliquot corresponding to about 4 gm. of the original muscle was placed on a 'Dowex-1' column in the chloride cycle, with a bed volume of either 5 or 7 ml. Elution was carried out according to Cohn and Carter[2] except that 0·005 *N*, instead of 0·003 *N*, hydrochloric acid was used, and this was used as the first eluant.

With this system, the results previously obtained[1] were verified. With 0·005 *N* hydrochloric as eluant, adenine was eluted at 2–4 bed volumes and inosinic acid at 15–17 bed volumes. A long trailing peak was eluted at about 50–100 bed volumes, and this was identified as adenosine diphosphate. Usually, elution was stopped after 40 bed volumes of 0·005 *N* hydrochloric acid and the next eluant started. In diastolic hearts no further peaks were obtained with the first eluant; but in systolic hearts another peak came off the column at 22–27 bed volumes, which corresponded to the previously identified nucleotide *H*. This fraction was collected, neutralized to *p*H 7, and concentrated *in vacuo* at a temperature below 50° C. On phosphorus analysis[5], one organic and usually one inorganic phosphorus were obtained per mole adenine, determined spectrophotometrically. Occasionally more than one inorganic phosphorus was obtained. On paper chromatography, using Hanes and Isherwood's[6] method to determine the phosphorus spots, and Magasanik's[7] method to determine the purine spots, a phosphorus spot was always associated with the purine spot, at an R_F value that corresponded to adenylic acid. On mixing some of the unknown with authentic adenylic acid, the purine spots could not be separated on paper.

Furthermore, on paper chromatography there were always two ninhydrin spots identified as aspartic and glutamic acids, with occasionally a third one identified as alanine. Again, on mixing the unknown with authentic glutamic and aspartic acids, no separation occurred on paper.

On rechromatography on 'Dowex-1', or following the precipitation of the nucleotides with mercuric acetate[8], the two amino-acids and the adenylic acid spots were always present, and yet they never chromatographed as one unit on paper. Using the solvent system, *iso*butyric acid/ammonia/water, 66 : 1 : 33, the R_F value for nucleotide *H* was 0·51, adenylic acid 0·51, glutamic acid 0·45, and aspartic acid 0·35. A mixture of adenylic, aspartic and glutamic acids acted in all respects like nucleotide *H*.

Thus, in conclusion, the previously named nucleotide *H* is only an artefact made up of adenylic, aspartic and glutamic acids. On the anion exchange resin, 'Dowex-1', it happened that these three compounds are eluted from the column at the same rate, and are precipitated together by mercuric acetate.

The reason why the two amino-acids appear only in systolic hearts remains to be investigated.

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Biochemical Differentiation of Group *A* and 'Human *C*' *Streptococci*

Most *Streptococci* are satisfactorily differentiated by relatively simple biochemical methods. Among the exceptions are *Streptococcus pyogenes* (group *A*) and the 'Human *C*' *Streptococcus* (group *C*), which are differentiated with reliability only by Lancefield's serological technique[1]. Wilson and Rosenblum[2] showed that 477 cultures of *S. pyogenes* failed to multiply in raw milk sterilized with ethylene oxide while 31 cultures of group *C Streptococci*, of which at least 11 were 'Human *C*', always grew well in this medium. Recently, Levinson and Frank[3] have published a method utilizing bacitracin for the differentiation of group *A Streptococci*. Approximately 10 per cent of their 67 group *C* strains were not differentiated. They mention the possibility of resistant group *A* strains emerging as a result of the clinical use of bacitracin. Since *S. pyogenes* and 'Human *C*' *Streptococci* are not readily distinguished biochemically by any single test or combinations of such tests[1,4] in present use, a medium and method of differentiating them are of interest.

A medium for this purpose is prepared as follows. 5 ml. of commercial rennet extract is added to 1 litre of fresh, antibiotic-free, raw milk tempered to 40° C. The resulting curd is cut into cubes, and the whey is strained through a cheese-cloth, after which it is centrifuged for a few minutes. Clear whey is removed from the sediment and milk-fat with an aspirator and filtered twice through Whatman No. 42 filter paper, then through a Selas 02 bacteriological filter candle previously autoclaved after being charged with 0·1 *N* hydrochloric acid. The sterile medium is dispensed into sterile test-tubes and incubated for 24 hr. at 37° C. as a sterility check. Tubes showing turbidity are discarded.

Several precautions must be observed in the preparation and care of the test medium. The milk must be raw (unheated) as *S. pyogenes* is able to multiply in heated milk. The raw milk must be free from antibiotics as residual antibiotic resulting from mastitis therapy prevents the growth of 'Human *C*' *Streptococci* in milk. Incubation of the test medium after sterilization is necessary since results are based on turbidity. Prepared medium should be stored in the dark since it is known that exposure to light for extended periods of time eventually allows a slight growth of *S. pyogenes* in raw milk serum. It is necessary to filter the medium twice through filter paper before sterilization or the medium will plug the filter candle before any quantity is obtained.

To differentiate between cultures of *S. pyogenes* and 'Human *C*' a loopful of culture is inoculated into tubes of the sterile, raw milk serum medium. The tubes are incubated for 24 hr. at 37° C. Growth, as shown by turbidity, indicates the presence of 'Human *C*' *Streptococci*. Lack of growth (no turbidity) indicates the presence of *S. pyogenes*.

Nine cultures[5], six of *S. pyogenes* and three of 'Human *C*' *Streptococci*, were grown in meat-infusion broth. They were transferred daily for several weeks and then kept one month in broth without transfer. For the remainder of the test period of six months these cultures were transferred weekly, except for the last week, when they were again transferred daily. The six strains of *S. pyogenes* never multiplied in the raw milk serum medium, as shown in Table 1. This was true when the cultures were young (18 hr.), old (1 month), and transferred daily, weekly or sporadically. The 'Human *C*' cultures always grew in the test medium under the same conditions, attaining counts of greater than 200 million per ml.

Table 1. The Growth of *Streptococcus pyogenes* and 'Human *C*' Streptococci subcultured Periodically in Raw Milk Serum Medium

Culture number and group		Subcultured								
		Daily		Weekly		Monthly			Sporadically		
		1	2	1	2	1	2	3	1	2	3
C203S	(*A*)	−	−	−	−	−	−	−	−	−	−
A4	(*A*)	−	−	−	−	−	−	−	−	−	−
A6	(*A*)	−	−	−	−	−	−	−	−	−	−
A8	(*A*)	−	−	−	−	−	−	−	−	−	−
A9	(*A*)	−	−	−	−	−	−	−	−	−	−
A11	(*A*)	−	−	−	−	−	−	−	−	−	−
C519	(*C*)	+	+	+	+	+	+	+	+	+	+
C556	(*C*)	+	+	+	+	+	+	+	+	+	+
7078	(*C*)	+	+	+	+	+	+	+	+	+	+

−, No growth. +, Profuse growth.

Others[2] have shown that the property of growth or lack of growth in the raw milk serum medium characterizes many more strains of *S. pyogenes* and 'Human *C*' *Streptococci* than the nine reported here. The procedure previously used required a streak plate after culture in the differentiating medium because of the opacity of the differentiating medium. The medium described here was prepared in the course of another investigation[6] and the necessary testing of a large number of cultures was not possible. It is felt that the simplicity of the turbidimetric method and its potential value in the biochemical scheme of differentiation of *Streptococci* justify a report based on a limited number of cultures.

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Effect of Insulin and Phenazine Methosulphate on Pathways of Glucose Catabolism in the Mammary Gland of the Rat

There is considerable evidence that a large part of the glucose catabolism of the lactating mammary gland of the rat occurs by way of the pentose phosphate pathway[1]. The effect of insulin on the relationship between glucose utilization and fatty acid synthesis has recently been investigated by Abraham *et al.*[2], who have shown that the addition of insulin to mammary gland slices from lactating rats caused an increased production of carbon dioxide labelled with carbon-14 from (1-^{14}C)glucose and an increased incorporation of glucose carbon into fatty acids.

There is also growing evidence that one of the factors controlling the activity of the pentose phosphate pathway in many tissues is the supply of

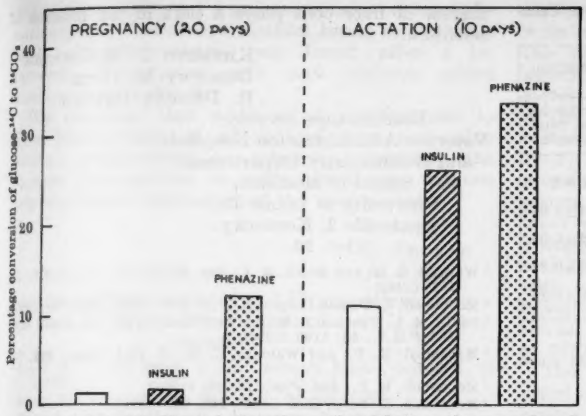

Fig. 1. Effect of insulin and phenazine methosulphate on the conversion of (1-^{14}C)glucose to labelled carbon dioxide by mammary gland slices from pregnant and lactating rats. 500 mgm. mammary gland slices incubated with 4·5 ml. Krebs–Ringer bicarbonate solution and 20 mgm. glucose containing 0·2 μc. (1-^{14}C)glucose. Gas phase oxygen + carbon dioxide (95 : 5). Incubation period 90 min. at 38° C. Additions to flasks: 1 I.U. insulin or phenazine methosulphate (final concentration 1×10^{-4} *M*)

oxidized triphosphopyridine nucleotide[3–5]. In the lactating mammary gland, as in most animal tissues, triphosphopyridine nucleotide is present almost exclusively in the reduced form[6]. It seemed possible that the stimulation of a reductive synthetic process utilizing reduced triphosphopyridine nucleotide, such as fatty acid synthesis, could lead to a parallel increase in the activity of the pentose phosphate pathway. One of the sites of action of insulin in the mammary gland might therefore be localized in the process of fatty-acid synthesis, the stimulation of which could produce a secondary effect on the activity of the pentose phosphate pathway. Evidence for this has been obtained from a study of the effect of insulin and phenazine methosulphate on the oxidation of either (1-^{14}C)glucose or (6-^{14}C)glucose by rat mammary gland slices at different functional stages. The results of some of these experiments are summarized in Fig. 1.

The marked difference in the effect of insulin on the oxidation of (1-^{14}C)glucose by tissue slices from pregnant and lactating rats can be seen in the histogram. Insulin has very little effect on the low rate of production of carbon dioxide labelled with carbon-14 by mammary tissue from pregnant rats, but causes a doubling of the rate of formation of labelled carbon dioxide by slices of lactating mammary gland. It seems probable that this difference between the glands from pregnant and lactating animals is related to their fat synthesizing capacity. Whereas the lactating gland has been shown to respond to treatment with insulin by an increase in the rate of formation of fatty acids[3,7], no such effect can be demonstrated in the mammary gland from pregnant rats.

The addition of phenazine methosulphate to slices of lactating mammary gland results in a stimulation of formation of labelled carbon dioxide from (1-^{14}C)-glucose as great as that found with insulin and, it should be noted, it produces an even more striking effect, a ten-fold increase, in slices of mammary tissue from pregnant animals. A series of other artificial electron acceptors produced similar effects.

The oxidation of carbon-6 of glucose is increased, but to a very much lesser extent, by the presence of phenazine methosulphate; insulin caused a pronounced decrease in the formation of labelled carbon dioxide from (6-^{14}C)glucose by mammary tissue from lactating rats. The increased production of labelled carbon dioxide from (1-^{14}C)glucose may thus be attributed mainly to an increased formation of labelled carbon dioxide by way of the first two, triphosphopyridine nucleotide-linked, steps of the pentose phosphate pathway.

It is suggested that the effect of phenazine methosulphate and of insulin in increasing the oxidation of glucose by way of the pentose phosphate pathway is mediated by increasing the rate of re-oxidation of reduced triphosphopyridine nucleotide; in the case of phenazine methosulphate by acting as an electron acceptor and of insulin by promoting the utilization of the hydrogens in the synthesis of long-chain fatty acids (see Hele, ref. 8).

This work will be reported in detail elsewhere.

The crystalline insulin, free from hyperglycæmic-glycogenolytic factor, used in these experiments was kindly given by Dr. Hallas-Møller, Novo Terapeutisk Laboratorium.

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Partition of Selenium-75 in the Intracellular Particulate Matter of Rat Liver

In the mammalian organism there is an apparent fixation of trace amounts of selenium in various tissue proteins. This has been demonstrated in studies of proteins from blood[1,2], liver[3,4] and leukocytes[5]. Hydrolysates of purified protein[4] of dog liver labelled with selenium-75 contain at least three different compounds with radioselenium. These compounds behaved like amino-acids in ion-exchange and precipitation studies and appeared on paper chromatograms in the (*a*) cystine and selenocystine, (*b*) methionine and selenomethionine, and (*c*) leucine areas. Neither the metabolic pathway or process by which inorganic selenium is converted to organo-selenium nor the biological function of selenium is known. Since time-distribution studies[6] have revealed that the highest average concentration of 19 per cent of the dose was found in the liver, and since the liver is generally considered the main site of protein synthesis, we have undertaken to study the distribution of selenium-75 in the intracellular particulate matter of rat liver.

Three adult male rats were injected subcutaneously with a single dose of selenious acid labelled with selenium-75 which contained approximately 0·225 mc.

Table 1. Distribution of Selenium-75 in Rat Liver Cells (Values represent average of three experiments)

	Total selenium-75		Protein-bound selenium-75*	
	Percentage uptake	Activity per mgm. total nitrogen	Percentage uptake	Activity per mgm. total nitrogen
Homogenate	100·0†	1·00‡	80·3 ± 2·3	1·00‡
Nuclear fraction	2·7 ± 0·4	0·41 ± 0·04	87·4 ± 11·5	0·44 ± 0·03
Mitochondria	31·0 ± 1·6	0·66 ± 0·07	91·7 ± 2·2	0·76 ± 0·08
Microsomes	8·9 ± 1·7	1·26 ± 0·32	88·7 ± 5·1	1·39 ± 0·32
Soluble fraction	54·6 ± 1·1	1·47 ± 0·09	54·6 ± 3·7	1·00 ± 0·10

* Material insoluble in trichloracetic acid.

† 1 ml. homogenate = 23,673 c.p.m. (Exp. 1); 28,372 c.p.m. (Exp. 2); 28,842 c.p.m. (Exp. 3).

‡ Whole liver homogenate, 1·00.

of radioselenium and 0·03 mgm. of selenium per rat. The fasted animals were killed 24 hr. later, and the livers were removed, weighed and perfused with and homogenized in cold 0·44 *M* sucrose. Fractionation of the homogenate was performed essentially by the method of Dounce *et al.*[7]. Radioactivity was determined on aliquots of the homogenate and the nuclear, mitochondrial, microsomal and supernatant fractions. The nuclear and the mitochondrial fractions were washed three and two times respectively with 0·44 *M* sucrose. Total nitrogen was determined by the micro-Kjeldahl method of Clark[8]. Protein-bound selenium was determined by the standard tricholracetic method.

Results revealed that about one-half and one-third of the total selenium-75 activity, expressed as a percentage of the homogenate, were found in the soluble and mitochondrial fractions respectively, with smaller amounts in the remaining fractions. Total activity recovered was 97·2 ± 0·5 per cent, and total nitrogen recovery was 98·9 ± 4·2 per cent. The uptake of selenium-75 per mgm. of total nitrogen was found in decreasing amounts in the soluble, microsomal, mitochondrial and nuclear fractions respectively. The amount of selenium-75 precipitated with trichloracetic acid in all the fractions ranged from 70·1 to 96·2 per cent, except in the soluble fraction, where 48·5–57·9 per cent was found. Expressing the values on the protein-bound selenium basis, it was found that the microsomes had the highest values while the nuclear fraction had the lowest.

The preliminary studies on liver cell fractionation showed a wide but varied distribution of selenium-75 in the particulate matter. Expressed as protein-bound selenium-75 per mgm. nitrogen, the microsomes appeared to be the principal protein intracellular site of the uptake of radioselenium. However, the total amounts of selenium-75 activity in the soluble and mitochondrial fractions, which represent protein and non-protein radioselenium, respectively, were greater than those found in the microsomal and nuclear fractions.

Since fixation of selenium-75 in protein was found in all fractions studied, it appears that this phenomenon is not unique for any particular fraction. These findings are consistent with previous observations that trace amounts of selenium are fixed in a variety of proteins. On the other hand, the fact that all subcellular structures are able to fix selenium-75 in proteins may mean that all the particulate matter of liver cells plays a part in the fixation of selenium.

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Action of Nicotinamide on Acetoacetate Metabolism of Liver Homogenates of Normal and Alloxanized Rats

The results of *in vivo* studies show that nicotinamide has a ketogenic effect on alloxanized rats[1,2]. On the other hand, Villa and Dioguardi[3] observed that nicotinamide considerably increases the oxygen consumption of liver homogenates of normal rats in a medium containing sodium acetoacetate, and they suggested that this effect is the result of stimulation of the keto-oxidative system. Recently, we observed[4] that the rate of oxygen uptake of liver homogenates of alloxanized rats rises after the addition of ethyl acetoacetate; but the oxygen consumption is not relatively higher after the addition of nicotinamide.

In the present study two series of tests were made in order to determine the effect of nicotinamide on oxygen and acetoacetate uptake of liver homogenates of alloxanized rats in media containing sodium acetoacetate in a Warburg respirometer at 30·4° C. We found: (1) The rate of oxygen uptake of the liver homogenate rises after the addition of sodium acetoacetate. Nicotinamide induces a further increase (Table 1). (2) Using liver homogenates from 25 rats under the same conditions, no significant difference in amount of acetoacetate (measured by two

Table 1

Homogenates	Media	Oxygen uptake mm.³/hr. ± S.E.
Liver 100 mgm.	Buffer (phosphate pH 7·4)	23·46 ± 1·7
	Buffer + sodium acetoacetate (18 mgm. approximately)	36·25 ± 1·9
	Buffer + sodium acetoacetate + nicotinamide (2 mgm.)	52·14 ± 3·0

Table 2

Homogenates	Media	Amount of total acetone (in mgm.) after an incubation of 4 hr. ± S.E.
Liver 200 mgm.	Buffer + sodium acetoacetate (18 mgm. approximately)	7·54 ± 0·21
	Buffer + sodium aceto-acetate + nicotinamide (2 mgm.)	7·48 ± 0·17

different methods) (ref. 5 and unpublished data of the authors, by a colorimetric method, based on Gerhart's ferric chloride reaction) was found after 4 hr. between experiments with and without added nicotinamide (Table 2).

We conclude that addition of nicotinamide to liver homogenates of alloxanized rats, containing sodium acetoacetate as substrate, increases the oxygen consumption in some conditions without any significant utilization of the acetoacetate.

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Sparing Effect of Serum from Mice treated with Endotoxin upon Certain Murine Virus Diseases

Bacterial endotoxin has a complex pharmacological action upon animals; this includes a febrile response beginning about 2 hr. after its intravenous or intraperitoneal inoculation. Blood serum from dogs[1] and rabbits[2] 2 hr. after the inoculation of endotoxin contains a pyrogen distinct from endotoxin[3,4]. It has been termed 'endogenous pyrogen' and is believed to be produced by damaged cells, notably leucocytes. Indeed, it has been suggested that cells damaged in ways other than by endotoxin produce endogenous pyrogen and that endogenous pyrogen may be the factor common to fevers of diverse etiology[4].

It has been shown that mice treated with endotoxin have increased susceptibility to the pathogenic action of ectromelia virus[5]. The facts mentioned above with regard to endogenous pyrogen suggested that the inoculation of serum of mice bled 2 hr. after injection with endotoxin might increase the susceptibility of mice to ectromelia virus in the same way as the inoculation of endotoxin. This possibility was tested as follows. Adult mice (strain *VS*) were bled 1¾–2¼ hr. after inoculation of endotoxin present in growth filtrates of *Salmonella typhimurium*[6]. Normal serum was prepared from comparable mice uninoculated with endotoxin. Each serum was inoculated intraperitoneally into 20 weanling mice (0·4 ml.), and 3 hr. afterwards both groups of mice, together with a group of 20 control mice, were inoculated intraperitoneally with 5 *LD*50 of ectromelia virus. A similar experiment in which the sera had been heated at 56° C. for ½ hr. was also carried out.

Table 1

Source of serum	Unheated serum: Survival-rate 7 days after virus inoculation. Mice surviving/Mice in group	Unheated serum: Probability that difference is due to chance χ^2	Unheated serum: Probability that difference is due to chance P	Heated serum: Survival-rate 8 days after virus inoculation. Mice surviving/Mice in group	Heated serum: Probability that difference is due to chance χ^2	Heated serum: Probability that difference is due to chance P
Endotoxin-treated mice	18/20	10·7	0·001	13/20	6·5	0·01
Normal mice	7/20			4/20		
Controls (no serum)	9/20			8/19		

The proportion of mice in each group which survived on the first day on which the mortality of the controls exceeded 50 per cent is shown in Table 1. It will be seen that significantly more of the mice survived which had received serum from endotoxin-treated mice, whether heated or unheated. The result was opposite to that expected, and suggested the presence in serum from mice treated with endotoxin of a substance which raises the resistance of mice to ectromelia virus. These experiments have been repeated with similar results.

Since the method of production of the protective serum has no obvious connexion with ectromelia, we considered that it might act in a similar way with other infections. We therefore studied its effect upon the mortality-rate which results from the dual infection of mice with *E. coccoides* and mouse hepatitis virus (*MHV* 1). It will be recalled that whereas *E. coccoides* is a harmless blood parasite of mice and mouse hepatitis virus causes a mild non-fatal hepatitis, infection of mice with *E. coccoides* followed by mouse hepatitis virus results in an acute hepatitis which is fatal in weanling mice[7,8].

Groups of 50 weanling mice were inoculated intraperitoneally with *E. coccoides* (0·2 ml. of blood containing the parasite diluted 10^{-6}) 24 hr. before the intraperitoneal inoculation of 10 *LD*50 of virus. Some groups were kept as controls, others were inoculated intraperitoneally with sera 3 hr. before the virus as in the previous experiments but the dose of serum was reduced to 0·2 ml. The results are shown in Table 2.

The proportion of survivors is higher in mice which received serum from mice reacting to endotoxin, whether fresh or heated, than in mice which received normal serum. The higher survival-rate in mice which received normal serum compared with that of the control mice which received no serum conformed to previous experience[9].

Preliminary experiments indicate that serum from rabbits reacting to endotoxin increases the resistance of mice to ectromelia; rabbit serum has not yet been tested against *E. coccoides*–*MVH* 1 infection.

Table 2

Source of serum	Unheated serum: Survival-rate: Mice surviving / Mice in group	Unheated serum: Probability that difference is due to chance χ^2	Unheated serum: Probability that difference is due to chance P	Heated serum: Survival-rate: Mice surviving / Mice in group	Heated serum: Probability that difference is due to chance χ^2	Heated serum: Probability that difference is due to chance P	Total: Survival-rate: Mice surviving / Mice in group	Total: Probability that difference is due to chance χ^2	Total: Probability that difference is due to chance P
Endotoxin-treated mice	36/49	5·2	< 0·05	35/49	3·5	< 0·1	71/98	9·5	< 0·01
Normal mice	24/49			25/49			49/98		
Controls (no serum)	16/48			13/49			29/97		

These results suggest the possibility that serum from animals reacting to endotoxin might show a similar protective effect against a wide variety of infections. We also consider that the protective substance may be present in the blood serum of animals reacting to toxic agents other than endotoxin, by analogy with the idea that endogenous pyrogen is produced by tissues damaged by diverse pyrogenic agents. These possibilities and the nature of the protective substance are being studied.

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Isolation of a Lipopolysaccharide from *Vibrio fetus*

Vibrio fetus infection is an important cause of infertility in cattle throughout the world. Little is known of the pathogenesis of this disease, partly because of the difficulty of obtaining massive growth of the vibrio *in vitro*. The recent development in this laboratory of a method of obtaining satisfactory yields of cells[1] has enabled fractionation studies on *Vibrio fetus* to be undertaken.

A toxic lipopolysaccharide has been isolated by the phenol extraction method of Westphal *et al.*[2]. Before extraction, flagella were detached by shaking the cells in sterile saline for 1 hr.[3], and surface antigens removed by treatment with 0·5 *M* potassium thiocyanate for 72 hr. at 37° C.[4]. The lipopolysaccharide was dialysed at 0° C. to remove all traces of phenol and gave a viscid, opalescent solution. An apparently identical lipopolysaccharide has been recovered from both smooth and rough forms of *Vibrio fetus*.

The substance conforms to the general characteristics of the lipopolysaccharides of Gram-negative bacteria in being toxic, pyrogenic and antigenic. Examination of a sample of the lipopolysaccharide by Dische's sulphuric acid – cysteine method[5] revealed the presence of an aldoheptose component. The absorption spectrum in a Hilger 'Uvispek' showed a curve suggestive of a lipopolysaccharide with a minimum contamination with nucleic acid. Hydrolysis with 1 per cent (v/v) acetic acid at 100° C. for 3 hr. yielded a small amount of a chloroform-soluble lipid.

The toxicity and pyrogenicity is greatly enhanced by heating the solution at 80° C. for 5 min. Rabbits are particularly susceptible, and deaths have occurred at the dose-level of 400 μgm./kgm. administered intravenously. The lethal dose is reduced to 40 μgm./kgm. rabbit by pre-heating. Nevertheless, rabbits withstand intramuscular injections of 10 mgm. of unheated lipopolysaccharide solution without apparent ill-effects. Mice are less susceptible, and the lethal dose is in the vicinity of 2 mgm. administered intravenously.

A febrile response in rabbits may be elicited with as little as 4 μgm./kgm., and the pyrogenic dose is reduced by heat treatment to as low as 0·005 μgm./kgm. Increases in temperature of 3–7·9° F. have been recorded. The temperature rises sharply within the first hour, reaches a peak in the majority of cases in 3 hr. and slowly falls to normal. The return to normal may take more than 24 hr.

Lipopolysaccharides, from both smooth and rough variants, are adsorbed on to human 'O' erythrocytes and give hæmagglutination when tested against homologous *Vibrio fetus* whole-cell rabbit antisera. The use of *Vibrio fetus* lipopolysaccharide in such a test may be of value in providing earlier and more accurate diagnosis of the disease in cattle. The lipopolysaccharide is a suitable antigen in the 50 per cent-hæmolysis-unit complement-fixation test using *Vibrio* antisera from rabbits. Further serological studies with this lipopolysaccharide are being undertaken.

I wish to thank Mr. R. V. S. Bain and Dr. K. Knox for their help and advice in these studies.

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Effect of Lytic Enzyme from *Bacillus circulans* and Chitinase from *Streptomyces* sp. on *Aspergillus oryzae*

The enzyme contained in a culture fluid of *Bacillus circulans* has been shown to exert lytic activity towards *Aspergillus oryzae* and that a polymer of melibiose was liberated from the cell wall. However, the cell wall was not completely lysed by the enzyme owing to the large amount of chitin present. During the search for enzymes causing lysis of fungal cells, it was found that a mixed preparation of chitinase and lytic enzyme exerted strong lytic activity on the cell wall of *A. oryzae*.

In this communication some observations pertaining to the action of chitinase and lytic enzyme, and to the fine structure of the cell wall are given.

The cell wall and the lytic enzyme were prepared by methods previously described. The crude chitinase was used as a chitinase preparation[1]. The mycelia of *A. oryzae* which had been previously shaken in the peptone–starch medium for 12 hr. at 30° C. was used as intact cells. Washed living mycelia and the cell wall were suspended in the various enzyme solutions using *tris*-buffer *M*/50, *p*H 6·8 and were incubated at 37° C. Turbidity of the suspension was determined by the Itô Beckman type spectrophotometer at 10-min. intervals over a period of 1½ hr.

As shown in Fig. 1, the lysis progressed more rapidly when the lytic enzyme was added together with the chitinase than when added alone. Moreover, after 2 hr. had elapsed scarcely any cell wall and intact cells could be detected by either a phase-contrast microscope or an electron microscope.

40 mgm. of the cell wall were suspended in a solution consisting of 20 ml. of the lytic enzyme solution, 20 ml. of the chitinase solution or 20 ml. of the

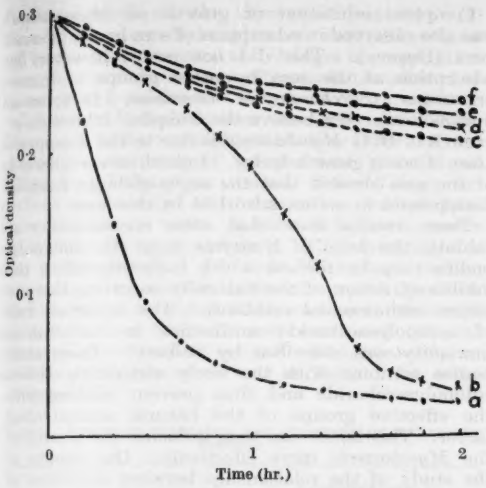

Fig. 1. Action of lytic enzyme and chitinase on the cell wall and on intact cells. Washed intact cells and cell wall were suspended in enzyme solutions (*tris*-buffer *M*/50, *p*H 6·8), and were incubated at 37° C. *a*, Cell wall (enzymes: lytic enzyme + chitinase); *b*, intact cells (enzymes: same as *a*); *c*, cell wall (enzyme: chitinase); *d*, cell wall (enzyme: lytic); *e*, intact cells (enzyme: lytic); *f*, intact cells (enzyme: chitinase)

chitinase and the lytic enzyme solution. About 5-ml. portions of this mixture were sampled at 30-min. intervals, and hexose and hexosamine liberated from the cell wall were determined by the anthron method[3] and by the modified method[4] of Elson and Morgan. Fig. 2 shows the experimental results.

From these results, it is concluded that the chitin-like fibre located on the cell wall is not chitin alone,

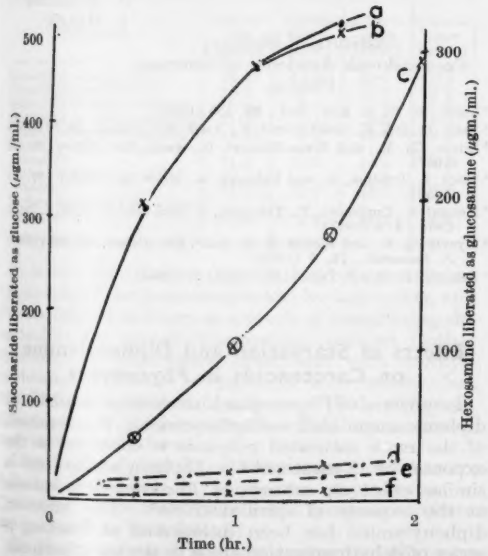

Fig. 2. Lytic action of lytic enzyme and chitinase on the cell wall. 40 mgm. of cell wall was suspended in 20 ml. of enzyme solution (*tris*-buffer *M*/50, *p*H 6·8), and these mixtures were incubated at 37° C. *a*, Saccharide (enzyme: lytic enzyme 24 μgm./ml. as N); *b*, saccharide (enzymes: lytic enzyme 24 μgm./ml. as N + chitinase 20 μgm./ml. as N); *c*, hexosamine (enzymes: same as *b*); *d*, hexosamine (enzyme: lytic enzyme 24 μgm./ml. as N); *e*, saccharide (enzyme: chitinase 20 μgm./ml. as N); *f*, hexosamine (enzyme: same as *e*)

but chitin coated by a melibiose polymer which could be lysed by the lytic enzyme from *Bacillus circulans*.

We wish to express our appreciation to Drs. K. Sakaguchi and K. Arima for their valuable suggestions and to Drs. D. M. Reynolds and L. R. Berger who kindly sent us the chitinase.

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Factors inhibiting and stimulating Growth of *Mycobacteria* in the Blood and Serum of Non-immunized and Immunized Animals

RESISTANCE to infection with tuberculosis is determined by a number of factors, some of which restrict proliferation of the infective agent in the first stage of the infection. Various authors have demonstrated limitation of growth of the *Mycobacteria* not only in the cells of immunized animals but also in their tissue fluids[1–4].

In our experiments we first verified the results of Kotani *et al.*[5], obtained by culturing *Mycobacterium tuberculosis* (BCG) in drops of blood from healthy and infected rabbits. Like Kotani *et al.*, we found inhibition of growth of the *Mycobacteria* in the blood of the infected animals. On studying the relationship between the amount of inhibition of growth in the blood and serum of infected rabbits and the virulence of the strains or the amount of the infective dose, we found that small doses of a more virulent strain (total dose 0·1 mgm. and 0·4 mgm., intravenously) gave greater inhibition of growth.

We then studied the effect of different sera from normal and immunized rabbits on growth of BCG *Mycobacteria*. The method consisted in culturing BCG cells in a thin layer of 2 per cent glycerin agar on a slide in 2 ml. test serum. The agar was applied to the slide after mixing with a suspension of BCG *Mycobacteria* prepared by the method of Kotani *et al.*[5], in the ratio 10 : 1. After culturing for 48 hr. at 37° C., the slides were transferred to fresh serum and cultured for a further 48 hr. Growth of the *Mycobacteria* was then evaluated by counting the number of cells in each microcolony, as in the experiments of Kotani *et al.*

When BCG *Mycobacteria* were cultivated in the serum of normal rabbits, great differences in their growth activity were observed. In the sera of 24 rabbits examined in the course of one year, the average growth of *Mycobacteria* varied from 2·0 up to 7·5 rods per microcolony in different animals. This decrease of growth in individual sera may be due to a naturally occurring antimicrobial substance[6].

A further increase in the inhibitory action of rabbit sera was observed after immunization of these animals with killed vaccine of *M. tuberculosis* var. *bovis* (Duprey) (Table 1, Fig. 1, *a*, *c*). Heating the sera of non-immunized and immunized rabbits at 56° C. for 30 min. did not affect growth of the BCG cells;

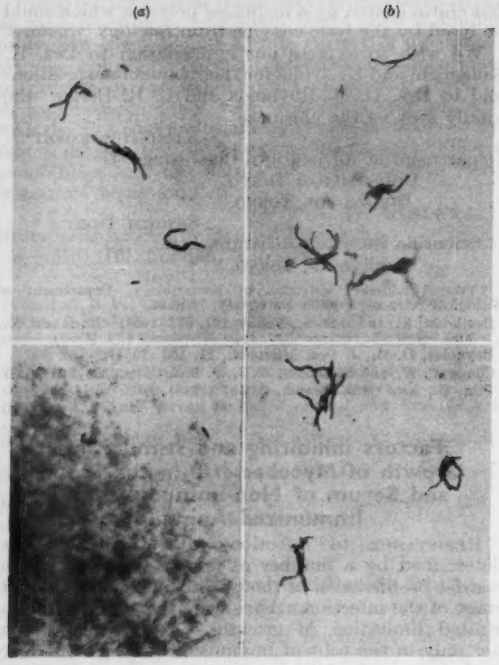

Fig. 1. Growth of cells of *Mycobacterium tuberculosis* var. *bovis* (BCG). (*a*) in serum of normal, non-immunized rabbits; (*b*) in the same sera heated to 70° C. for 30 min.; (*c*) in serum of immunized rabbits; (*d*) the same serum heated to 70° C. for 30 min. The rabbits were immunized intravenously with 4 mgm. inactivated vaccine (*M. tuberculosis* var. *bovis* (Duprey))

growth increased only when the sera were heated at 70° C. for 30 min. (Table 1, Fig. 1 *b*, *d*). In both groups of animals, growth of the *Mycobacteria* was then the same. It was further found that growth of BCG *Mycobacteria* was completely inhibited by adsorption of the sera of control animals by a concentrated suspension of living or killed cells of these *Mycobacteria*, and that it was not renewed even when the sera were heated at 70° C. This is the basic difference as compared with the serum of immunized rabbits, in which growth of BCG *Mycobacteria* was completely inhibited, but in which, on heating at 70° C., growth of BCG cells reached the same values as in the controls.

Table 1. Growth of Cells of *Mycobacterium tuberculosis* var. *bovis* (BCG) in Serum of Non-immunized and Immunized Rabbits. The Figures refer to the Average Number of Cells in the Microcolony

Rabbit No.	Immunization (mgm.)	Growth of BCG cells in serum			
		Control	Heated at 56° C.	Heated at 70° C.	Adsorbed by BCG
718	—	2·6	2·7	3·8	1·0
721	—	4·4	3·8	6·9	1·0
723	—	4·6	4·2	6·3	1·0
724	—	3·5	3·0	6·5	1·0
725	—	3·0	3·7	8·3	1·0
726	—	3·2	2·9	7·2	1·0
Average		3·5	3·4	6·5	1·0
22	4	1·0	1·0	5·4	1·0
168	4	1·0	1·0	7·2	1·0
170	4	1·0	1·1	3·1	1·0
171	4	1·2	1·1	9·6	1·0
174	4	1·1	1·0	8·7	1·0
Average		1·0	1·0	6·8	1·0

Complete inhibition of growth of *Mycobacteria* was also observed in adsorption of sera by *M. tuberculosis* (Duprey). This did not occur, however, in adsorption of the sera by other groups of microorganisms (*Saccharomyces cerevisiae*, *Diplococcus pneumoniae*). We believe the complete inhibition of growth of BCG *Mycobacteria* is due to the disappearance of some growth factor. Indeed, electrophoresis of the sera showed that the alpha-globulin fraction disappeared in serum adsorbed in this way.

These results show that after immunization of rabbits, the level of lysozyme may rise and antibodies may be formed which indirectly affect the inhibitory action of the naturally occurring thermostable antimicrobial substance. The important role of antipolysaccharide antibodies in tuberculosis immunity was described by Seibert[7]. These antibodies combine with the freely circulating tuberculopolysaccharide and thus prevent binding with the effective groups of the natural antimicrobial factor. This factor can then influence the growth of the *Mycobacteria* more effectively. Our results of the study of the relationship between inhibition of growth in rabbit serum and the size of the infection dose showed that the administration of large doses completely suppresses the inhibitory effect of the sera on growth of the *Mycobacteria*. This immunological paralysis is evidence that the inhibitory factor in the serum of immunized animals is of an antibody character.

It was also found that rabbit serum contains a substance promoting growth of *Mycobacteria* which can be removed by its adsorption by *Mycobacteria* suspensions and is to be found in the alpha-globulin fraction of serum. The activating effect of serum albumin[7] may be due to alpha-globulin which is carried over into the albumin in the commonly used fractionation procedures.

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Effects of Starvation and Diphenylamine on Carotenoids in *Phycomyces*

In cultures of *Phycomyces blakesleeanus* treated with diphenylamine and methylheptenone, the synthesis of the more saturated polyenes is enhanced at the expense of β-carotene[1,2]. Diphenylamine has a similar effect on cultures of *Rhodospirillum rubrum* at the expense of spirilloxanthin[3]. This effect of diphenylamine has been interpreted as blocking a series of dehydrogenation steps in the transformation of the more saturated to the less saturated carotenoids. Leucine, on the other hand, which stimulates production of β-carotene, contributes to intermediates in carotenoid synthesis.

Two effects are reported in this communication: (1) that of starvation of fully grown mycelial mats of

P. blakesleeanus on the carotenoid content; (2) those of β-ionone, diphenylamine, methylheptenone and leucine on the content and changes in composition when the starved mats are afterwards transferred to an energy-rich medium.

Cultures of *P. blakesleeanus* were grown in 250 ml. Erlenmeyer flasks containing a shallow layer (20 ml.) of medium consisting of 2·5 per cent glucose and 0·3 per cent Difco yeast extract. After 5 days, the medium was decanted off, the mycelium washed three times with sterile water, suspended in sterile water and kept for 24 hr. in the dark. The mycelium was then transferred to 1 per cent Wickerham carbon base medium together with the compound the effect of which was to be tested. The mats were harvested at definite time-intervals and examined for the carotenoids as described earlier[2]. Results are shown in Table 1 for β-carotene and in Table 2 for other components.

Table 1. Effect of Starvation and Transfer on β-Carotene Content

Treatment	β-Carotene (μgm.)				
	Experiment No.				
	1	2	3	4	5
Control (5 days growth)	30	33	31·6	32	—
Control (24 hr. starvation)	8·1	10·7	11·0	7	15·7
Control (24 hr. after transfer)	18·6	—	12·0	12	19
β-Ionone (24 hr. after transfer)	156·8	—	—	92	50
Diphenylamine (24 hr. after transfer)	—	—	31·0	—	45
Methylheptenone (24 hr. after transfer)	—	—	9·7	—	—
Leucine (24 hr. after transfer)	—	—	10·7	17	—
Control (no starvation; no transfer; that is, 6 days growth)	43·2	—	—	—	—

Table 2. Effect of Starvation and Diphenylamine on Polyene Content

Treatment	Phytoene (μgm.)	Phytofluene (μgm.)	β-Carotene (μgm.)	ζ-Carotene (μgm.)
Control (5 days growth)	33·6	12·3	29·1	3·4
Control (starved 24 hr.)	25·3	3·7	14·1	2·6
Control (1 hr. after transfer)	30·6	5·1	6·2	5·2
Control (4 hr. after transfer)	21·5	5·1	8·5	3·5
Control (12 hr. after transfer)	23·2	5·9	10·9	3·4
Diphenylamine (1 hr. after transfer)	74·0	10·0	24·4	4·3
Diphenylamine (4 hr. after transfer)	48·8	8·1	26·0	5·1
Diphenylamine (12 hr. after transfer)	53·3	7·8	24·3	4·7

It is seen from Tables 1 and 2 that between 50 and 75 per cent of the β-carotene is lost by starvation, and there is limited recovery as a result of transferring the control to the energy-rich medium without further treatment. Furthermore, treatment with methylheptenone, and more surprisingly with leucine, has no effect on β-carotene synthesis. With diphenylamine, however, the β-carotene-level of the pre-starved mat is rapidly restored.

Loss in β-carotene by starvation is not counterbalanced by gains in phytoene, phytofluene or ζ-carotene. (The neurosporene and lycopene contents are too small to be a factor.)

In the presence of diphenylamine the phytoene rises to a higher level than that in the pre-starved control. A net synthesis of phytoene has therefore occurred. This is not true of phytofluene, which although significantly higher than the starved and transferred control is still below the initial pre-starved level.

The effects of starvation and subsequent transfer on carotenoid-levels compared with those of the pre-starved may be summarized as follows:

Control, transferred: net losses in phytoene, phytofluene and β-carotene.

Treated with diphenylamine, transferred: net gain in phytoene, net loss in phytofluene, no change in ζ-carotene.

The restoration of β-carotene to virtually the pre-starvation-level as a result of treatment with diphenylamine requires explanation. Starvation causes no increase in other carotenoids at the expense of β-carotene. If, therefore, diphenylamine is to play its traditional part of anti-oxidant, it must be in preventing further breakdown of polyene precursors. Thus, 1 hr. after transfer, the β-carotene concentration is still decreasing in the control, whereas the trend is completely reversed in the cultures treated with diphenylamine.

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Changes in Œstrogen Titre in Stored Urine

Numerous examples of microbiological reactions on steroids have been reported, and it has been suggested that the presence of bacterial enzymes in urine may cause steroid transformations[1].

In preliminary experiments designed to exaggerate any changes which might occur in the œstrone, œstradiol-17β and œstriol values, urine was kept for several weeks, both at room temperature and at 4° C. Significant increases were found to occur in the œstrone and œstradiol-17β fractions of normal male urine but not in the œstriol fraction. Even more striking changes occurred in stored urine from an oophorectomized woman with carcinoma of the breast, collected after the injection of 2·5 mgm. of œstradiol-17β (Table 1).

The results of the chemical determination[2] were confirmed by biological assay (kindly carried out by Mr. P. C. Williams).

Accompanying changes in titre, considerable hydrolysis of the conjugated œstrogens occurs at room temperature. Four urines were analysed for

Table 1. Changes in Œstrogen Titre in Urine Stored for a Long Period
Results of duplicate estimations expressed as μgm./24 hr. For calculations of *P*, see Brown, Bulbrook and Greenwood (ref. 3)

	Initial	9 weeks at room temperature	*P*	10 weeks at 4° C.	*P*
Œstrone	3·3	17·7	< 0·001	64·3	< 0·001
Œstradiol-17β	3·2	7·1	< 0·001	0	< 0·001
Œstriol	3·1	3·2	—	0	< 0·001

Table 2. Urinary Œstrogen Titre under Normal Storage Conditions

	Initial	2 days at room temperature	6 days at 4° C.
Total œstrogen Mean	14·0	15·1	14·2
	(6)	(6)	(6)
S.D.	± 16·0	± 16·5	± 16·7

No. of duplicate estimations in parentheses. Results calculated as μgm./24 hr.

free œstrogens after ten weeks at room temperature; and from 62 to 74 per cent of the œstrone fraction, 0–45 per cent of the œstradiol-17β fraction, and 62–100 per cent of the œstriol fraction were found to be in the free form.

The increase in the œstrogen content of stored urine could possibly be accounted for by the transformation of one or more of the œstrogen metabolites known to be present in human urine but not measured by Brown's method. After four weeks on the bench or at 4° C. an increase from zero to 12 μgm. of œstriol was found in a specimen to which 16α-hydroxy-œstrone had been added, compared with no change in a control urine. Micrococci and diphtheroids were shown to be present in the urine but no attempt was made to determine whether the steroid transformation was due to the presence of these micro-organisms or to the increase in the alkalinity of the urine.

In normal circumstances changes have not been found to occur providing the urine is not kept for more than two days at room temperature or for more than a week at 4° C. (Table 2).

Although there were slight individual variations there is no significant difference between the three sets of results.

If urine is stored for any length of time, hydrolysis of the conjugates and destruction or transformation of the œstrogens may occur. The changes are not predictable or constant and unless analyses are carried out within two days at room temperature, or within one week at 4° C., the results may have little reference to the original titre of œstrone, œstradiol-17β and œstriol. However, it has been shown[3] that no loss of œstrogen occurred in a single specimen of urine stored at −10° C. for two months.

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Method for testing the Influence of Drugs and Physical Agents upon Mitosis

Jolly[1] described how to obtain a convenient number of erythroblastic mitoses in the circulating blood of various species of *Triturus*. The new techniques now made available by phase-contrast microscopy induced us to study these cells with time-lapse photography and micro-cinematography in order to obtain direct evidence of the mechanism of normal and artificially influenced mitosis.

The method can be summarized as follows. According to Jolly the newts are left absolutely without food for 2–6 months; after this period the animals are put in a thermostatic enclosure at 26° C. and fed for some days with earthworms. Generally, between the second and fourth day of feeding a good number of erythroblastic mitoses appear in the circulating blood of the newts. At this moment a blood smear is taken from the tail of the animals and stained as a control. Afterwards the newts are treated according to the aims of each particular experiment (intraperitoneal injections, exposure to radiations or gases, etc.); at various intervals small drops of blood are then taken from the tail of the animals, put on a slide, covered gently with a cover slide and sealed with paraffin.

The preparations are put under the phase-contrast microscope for time-lapse photography or cinematography; in order to keep the temperature constant during observation, the microscope is put in a special thermostatic enclosure. At the same time blood smears are prepared and stained. In certain cases it may be also advisable to act directly on the surviving erythroblasts of an untreated newt, adding the substance to the blood drop or exposing it to radiations, gases, etc.

Thus it is possible to follow and to document with films or photographs the course of mitosis and the various alterations eventually induced. Additional results are obtained from the stained smears.

Obviously, a great number of modifications to the method we have outlined may be necessary. In fact, our test is adaptable to many different experimental conditions, but is particularly suited when clear morphological evidence is needed. A series of detailed papers is in preparation, dealing with normal mitosis and the influence of various substances and physical agents upon it.

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Splitting of the Electrophoretic Pattern of Serum Albumin during Short-term Action of Pepsin at Room Temperature

The heterogeneity of serum albumins consisting of several molecular sub-units has been established by chemical as well as by electrophoretic assays. However, while chemical fractionation of serum albumins led to well-identified products, electrophoretic procedures did not show equally consistent results. In this latter case, the separation of the sub-units was found to vary with *p*H, ionic strength, length of run, and other factors not well understood[1]. It could be shown, moreover, that the splitting of albumin into a number of boundaries is a reversible process and does not represent denaturation on artefacts.

A similar but apparently irreversible splitting of serum albumin into molecular sub-units, by the short-term action of pepsin, is demonstrated in the present electrophoretic studies carried out by Tiselius's moving boundary method.

The analyses were initiated with crystalline bovine serum albumin (Armour). 100 mgm. albumin was dissolved in approximately 10 ml. distilled water

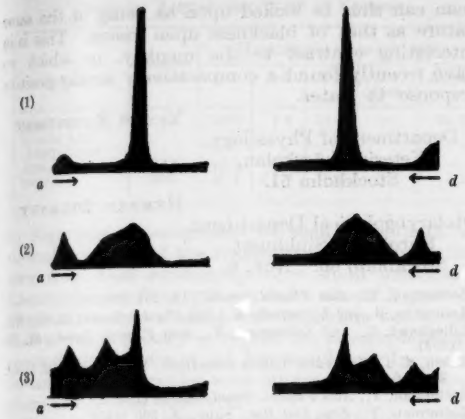

Fig. 1. Electrophoretic pattern of 1 per cent crystalline bovine serum albumin incubated with pepsin in a ratio 1 : 100 at room temperature: (1) at *p*H 7·0 for a 6-min. period; (2) and (3) at *p*H 3·0 for a 2- and 6-min. period respectively at room temperature

and the *p*H adjusted to 3·0. The solution was then incubated with 1 mgm. crystalline pepsin (Nutritional Biochemicals Corp.) at room temperature for 1–6 min., after which a proportional mixture of crystalline veronal and sodium veronal was dissolved in the sample in order to inactivate the ferment and to make its barbiturate – barbituric acid concentration equal to that of the buffer solution used in the electrophoretic experiment.

For the preparation of albumin from fresh cow, horse, rabbit and cock serum, a simple and relatively quick method had to be utilized that would be applicable to small amounts of blood, and which would provide an electrophoretically homogeneous product. The trichloracetic acid–acetone extraction procedure of Kallee and associates[2], modified slightly, gave satisfactory preparations. In most cases 3 ml. of the respective serum sample was used for the extraction. The acetone of the extract was removed by vacuum distillation at room temperature and the remaining aqueous suspension of albumin redissolved at *p*H 6·5 by addition of sodium hydroxide. The solution was clarified by high-speed centrifugation,

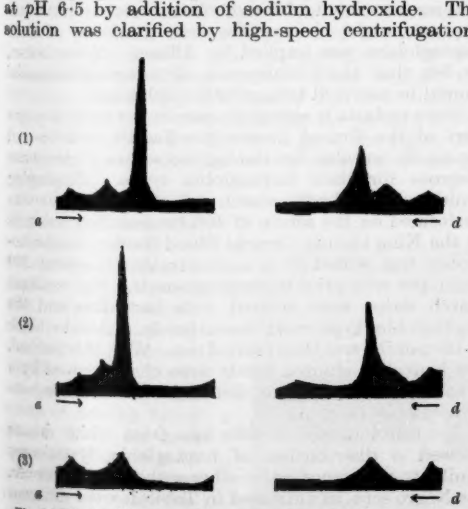

Fig. 2. Electrophoretic patterns of solution of (1) 0·87 per cent rabbit serum albumin, (2) 0·91 per cent cock serum albumin, and (3) 0·64 per cent horse serum albumin incubated with pepsin in a ratio 1 : 100 for a 6-min. period at room temperature

dialysed against 4 l. of distilled water in the cold for 24 hr., after which the *p*H was brought to 3·0 and incubated with pepsin in a 1 : 100 ratio as described above. The protein content of the samples was determined according to the method of Gornall *et al.*[3]. The readily reproducible electrophoretic assays were made in 2 ml. cells by means of a Perkin–Elmer electrophoretic apparatus, model 38, using veronal buffer of *p*H 8·6, ionic strength 0·1, and a potential gradient of 7·10 to 7·30 V./cm.

Fig. 1 shows the elctrophoretic pattern of 1 per cent crystalline bovine serum albumin after incubation with pepsin for 2 and 4 min., respectively. The two patterns differ primarily in the number and shape of their boundaries, which would indicate that the separation of the boundaries into two or three peaks depends upon the time-period allotted to the pepsin albumin constituents to react with each other.

Fig. 2 shows the electrophoretic pattern of rabbit, cock and horse serum albumin as influenced by the action of pepsin. On comparing the patterns of Figs. 1 and 2 the differences between the species different albumin samples are easily recognizable.

Thanks are due to Mr. J. A. G. Larose for valuable technical assistance.

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Has Water a Specific Taste?

In 1949 it was found that water applied to the tongue of the frog elicited an electrical response from the glossopharyngeal nerve[1]. This response was produced by specific fibres[2]. It was first thought that these 'water' fibres might serve a particular purpose in water regulation in amphibians living in fresh water. These findings also revived the old problem of whether warm-blooded animals and man possess similar specific taste fibres mediating what we might call a water taste. The late Prof. David Katz of Stockholm, who believed this to be the case, often asked in his examinations: What is the taste of water? The correct answer was 'wet'.

Such a belief was strengthened by the fact that Liljestrand[3] demonstrated that as weak a salt solution as 0·009 *M* sodium chloride which does not taste salty could be distinguished from distilled water with 100 per cent certainty if the solutions had been boiled and cooled down again to the same temperature.

Experiments on cats, dogs, pigs[3,4] and recently even monkeys have shown that these animals possess specific nerve fibres in their chorda tympani which respond to the application of water to the tongue. In the rat, on the other hand, an application of water to the tongue does not produce any positive response as it does in the cat; but a negative response is obtained which is due to an abolition of the rather high spontaneous activity of the salt fibres[5].

In the animals which possess specific water fibres as well as salt fibres, the discrimination of weak salt solutions from pure water could thus be elaborated by a dual system of salt and water fibres, the activities

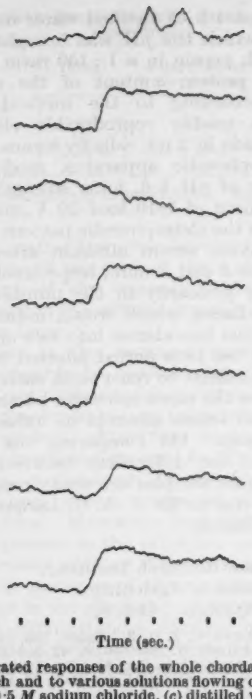

Fig. 1. Integrated responses of the whole chorda tympani nerve of man to touch and to various solutions flowing over the tongue: (*a*) touch, (*b*) 0·5 *M* sodium chloride, (*c*) distilled water, (*d*) 15 per cent sucrose, (*e*) 0·04 per cent saccharine, (*f*) 0·02 *M* quinine, (*g*) 0·2 *M* acetic acid

of which contrast with each other because of their reciprocal mode of stimulation, in the same way as do the cold and warm fibres in our thermal discrimination. A few years ago preliminary experiments on man were performed by Dr. C. Åhlander and one of us (Y. Z.) on man during operations on the middle-ear[6]. Out of ten trials very weak responses were obtained in two cases to touch, cold and gustatory stimulation of the tongue. The responses were, however, only very faintly audible in the loud-speaker and could not be recorded.

In recent attempts, made in the otological clinic of Karolinska Sjukhuset, we have been able to record the electrical response from the chorda tympani during operations carried out to mobilize the stapes in the middle-ear. In two out of six cases we have been able to record the integrated electrical response of the nerve when the tongue was stimulated by touch and various solutions. As will be seen in Fig. 1 there is a good response to 0·5 *M* sodium chloride solution as well as to 15 per cent sucrose, 0·04 per cent saccharine, 0·02 *M* quinine hydrochloride and 0·2 *M* acetic acid.

The application of water to the tongue, however, is followed by a negative response, in that water abolishes the spontaneous activity of the taste fibres just as has been described in the rat. As our evidence, however, is based upon successful experiments in only two humans, we have to collect more evidence before being able to say definitely that man lacks a specific water taste. Introspectively, however, it seems to us most likely that water does not elicit any positive taste sensation. The action must be of negative character in that water abolishes or decreases the resting activity of taste fibres, particularly that of salt fibres. The specific effect of water on taste in man can thus be looked upon as being of the same nature as that of blackness upon vision. This is in interesting contrast to the monkey, in which we have recently found a comparatively strong positive response to water.

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Haptoglobin Types in American Negroes

Since the discovery by Smithies[1] that there are genetically controlled serum haptoglobin types, two reports on the distribution of these types among African Negroes have been published. Sutton *et al.*[2] noted a 49 per cent incidence of haptoglobin type 1-1 among Liberian and Ivory Coast natives. A similar percentage (54 per cent) was found by Allison *et al.*[3] in Nigerians. However, a great discrepancy between the two studies was described by Allison, who found that 32 per cent of the Nigerian sera did not contain demonstrable haptoglobins—a condition not reported by Sutton. Allison pointed out that since the Michigan investigators did not add hæmoglobin to the sera prior to electrophoresis, and the starch gel was not stained with benzidine, sera devoid of haptoglobins could be readily confused with those of type 1-1.

Nosslin and Nyman[4] have shown that, in the presence of hæmolytic anæmia, the amount of serum haptoglobin may be greatly decreased or absent. That the high incidence of malaria and hæmoglobinopathies associated with red cell destruction in African Negroes might obscure the true incidence of their haptoglobins was implied by Allison. Nevertheless, he felt that the phenomenon of 'ahaptoglobinæmia' should be ascribed to a genetic mechanism.

Since malaria is extremely rare in the north-western part of the United States, the Seattle area seemed especially suitable for testing the serum of American Negroes for their haptoglobin types. Employing Smithies's method[5], starch gel electrophoresis was performed on the serum of 406 random Negro donors at the King County Central Blood Bank. Oxyhæmoglobin was added to a concentration of about 300 mgm. per cent prior to electrophoresis. The resultant starch strips were treated with benzidine and the haptoglobin type read immediately. Amido black *B*-10 staining was then carried out. With this method, the benzidine-stained bands were characterized by a permanent black colour distinct from the blue non-hæmoglobin protein.

A control group of 100 sera from white donors showed a distribution of haptoglobin types very similar to that reported by other authors[2,3,4]. However, the Negro sera, as indicated in Table 1, were different in several respects from those described in Africans.

Complete absence of haptoglobin was observed in a much smaller percentage of subjects than reported

Table 1. HAPTOGLOBIN TYPES IN NEGROES

Locale	Number tested	Haptoglobin types (per cent)				
		1-1	2-2	2-1	2-1 (mod.)	Absent
Nigeria (ref. 3)	99	53·5	3·0	11·1	—	32·3
Liberia and Ivory Coast (ref. 2)	142	48·7	9·1	42·3	—	—
Seattle	406	26·4	21·4	38·2	9·8	4·2

in Nigerians. Recognition of such individuals was difficult because of the necessity to distinguish their sera from that containing very small amounts of hæmoglobin-binding protein. In about 5 per cent of cases, the area stained with benzidine was so faint that it was necessary to repeat the electrophoresis to confirm the presence of haptoglobin. In several instances, new samples were obtained; but the same phenomenon was observed.

Seventeen, or 4·2 per cent of all sera tested, appeared to be completely devoid of haptoglobin. The donors of these samples were not anæmic and none had a history of malaria. Of six red cell specimens from 'ahaptoglobinæmic' Negroes neither unusual hæmoglobins nor a deficiency in glucose-6-phosphate dehydrogenase, which is associated with hæmolysis due to a variety of agents[7], could be demonstrated (hæmolysis performed by Dr. A. G. Motulsky, University of Washington School of Medicine). Inheritance studies of 'ahaptoglobinæmia' have so far been inconclusive. However, in some families, both parents of a subject with 'ahaptoglobinæmia' appear to carry a pair of normal haptoglobin genes. Thus, it is clear that if a genetic mechanism is involved, the responsible gene cannot be an allele at the *Hp* locus, nor can it be a Mendelian dominant.

Forty of the sera (9·8 per cent) showed a pattern similar to that of type 2-1, but distinctly different in having a much heavier concentration of haptohæmoglobin in the region just behind the beta-globulin (as seen in type 1-1) as well as the fastest of the zones in the 'alpha-beta' region. The other bands characteristic of type 2-1 were either entirely absent or scarcely discernible. In a recent paper, Connell and Smithies[8] describe the same unusual type, and illustrate the starch gel patterns of purified haptoglobins of this and the three common types. They suggest the tentative name '*Hp* 2-1 (mod.)' for this modified type. It is not yet known whether the pattern is due to a third allele at the *Hp* locus or to the effect of a modifying gene. Studies of its inheritance are in progress.

The lower incidence of 'ahaptoglobinæmia' and higher incidence of the Hp^1 gene in Seattle Negroes as compared with African natives may be explained by the following factors: (1) The present study was performed on the serum of healthy blood donors from an area essentially free of malaria. (2) Seattle Negroes represent several sections of Africa, where haptoglobin type distribution is probably variable. (3) Racial intermarriage in America, known to have produced an admixture of 30 per cent of European blood group genes in Negroes[9], undoubtedly has a similar influence on haptoglobin gene frequencies.

ELOISE R GIBLETT

King County Central Blood Bank,
Seattle, Washington. Nov. 18.

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Hæmoglobin *N* in Portuguese Guinea

IN 1956 a survey of hæmoglobin types in Liberians by Robinson, Zuelzer, Neel, Livingstone and Miller led to the discovery of two 'fast-moving' hæmoglobins which were provisionally designated Liberian I and II, the first abnormal complement moving on electrophoresis at *p*H 8·6 faster than the second and both moving faster than normal adult hæmoglobin *A*. Liberian I was at first supposed to be identical with hæmoglobin *J* discovered by Thorup, Itano, Wheby and Leavell[1]; but further study by Ager and Lehmann[2] demonstrated a difference in the behaviour of these hæmoglobins, Liberian I migrating faster than *J* at alkaline *p*H, though slower than *H* or *I*. At acid *p*H Liberian I separates from *A* towards the anode while *J* does not. Liberian I, thus being a new hæmoglobin, was called hæmoglobin *N*.

Hæmoglobin *N* is a rare type, having been found only eight times in the survey by Robinson *et al.*[3] among the Mande tribe in Central Liberia. During a survey of abnormal hæmoglobins in Portuguese Guinea we have found fourteen Africans with this rare variant. We are indebted to Dr. H. Lehmann, of the Department of Pathology, St. Bartholomew's Hospital, London, for having classified the abnormal hæmoglobin in the first instance when it was found. Fig. 1 shows its mobility on paper electrophoresis at *p*H 8·6 in the hands of this investigator. Subsequent hæmoglobins have been classified by ourselves in comparison with samples of hæmoglobins *J* and *H* very kindly supplied by Dr. Lehmann, the original hæmoglobin *N* found by us, and a sample of hæmoglobin *K* obtained at a previous survey in the St. Thomas and Prince Islands[4].

Hæmoglobin *N* was found in Portuguese Guinea in the following tribes in random samples of blood

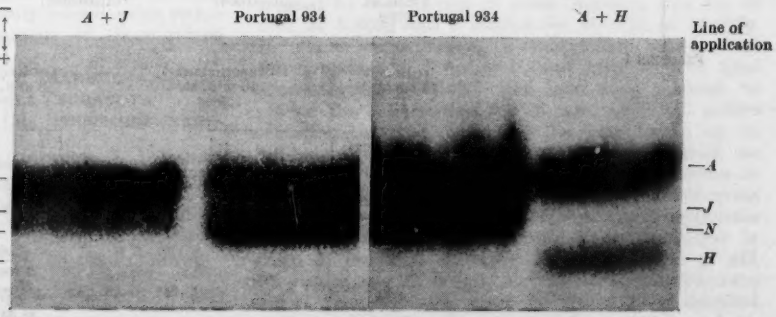

Fig. 1. Comparison of Portugal 934 with hæmoglobins *A*+*H* and *A*+*J*. It will be seen that at paper electrophoresis *p*H 8·6 the 'fast-moving' component of Portugal 934 is slower than *H* and faster than *J*

(number of samples given in parenthesis): Fula, 4 cases (1,553); Beafada, 1 (797); Pajadinca, 2 (300); Sôsso, 2 (94); Balanta, 1 (776); Mancanha, 1 (534); Manjaco, 3 (758).

The first four tribes are Moslems, the latter Fetichists. The general search allowed the examination of 9,224 samples of blood gathered throughout the Province.

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Oxygen Consumption of Different Forms of Stable L *Proteus* P 18 growing in Hypertonic Liquid Medium

In previous work we have studied the oxygen and glucose consumption as well as the lactic acid production of the *Proteus* Ahmed bacillus and of a stable L form which is derived from it[1].

We then noticed that the oxygen and glucose consumption of the bacillus were respectively 4·0 and 5·1 times higher than that of the L form, whereas the lactic acid production was only 2·4 times greater. The share of anaerobic glycolysis in the glucose

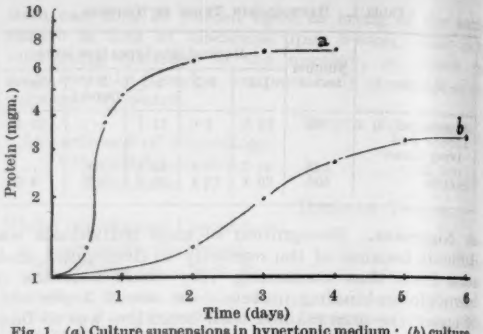

Fig. 1. (*a*) Culture suspensions in hypertonic medium; (*b*) culture films (*voiles*) according to Tulasne (ref. 2)

degradation was more considerable with the L forms than in the rod forms.

Owing to the heterogeneity of the L form cultures, it was interesting to investigate the metabolic characteristics of several morphological forms: large, small and elementary filterable bodies. First, a technique for obtaining readily large quantities of L forms was devised, because the usual methods[2,3] were found to be laborious and difficult. We have used films (*voiles*[2]) of L forms of *Proteus* P 18 to produce culture-suspensions in hypertonic medium. Our culture medium was composed of broth containing 20 per cent horse serum, 2,000 penicillin units per ml. and saccharose added to make up a final concentration of 0·3 *M*. Just after seeding, the

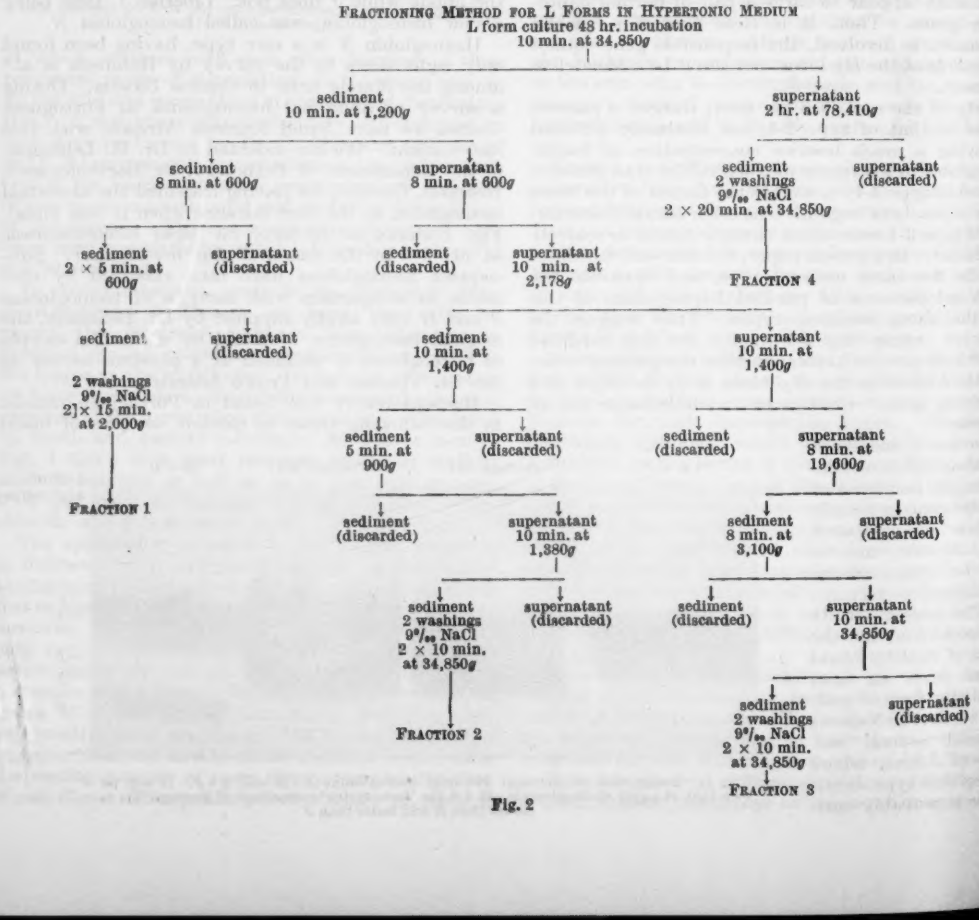
Fractioning Method for L Forms in Hypertonic Medium
L form culture 48 hr. incubation
10 min. at 34,850g
sediment 10 min. at 1,200g
supernatant 2 hr. at 78,410g
sediment 8 min. at 600g
supernatant 8 min. at 600g
sediment 2 washings 9‰ NaCl 2 × 20 min. at 34,850g
supernatant (discarded)
sediment 2 × 5 min. at 600g
supernatant (discarded)
sediment (discarded)
supernatant 10 min. at 2,178g
Fraction 4
sediment
supernatant (discarded)
sediment 10 min. at 1,400g
supernatant 10 min. at 1,400g
2 washings 9‰ NaCl 2] × 15 min. at 2,000g
sediment 5 min. at 900g
supernatant (discarded)
sediment (discarded)
supernatant 8 min. at 19,600g
Fraction 1
sediment (discarded)
supernatant 10 min. at 1,380g
sediment 8 min. at 3,100g
supernatant (discarded)
sediment 2 washings 9‰ NaCl 2 × 10 min. at 34,850g
sediment (discarded)
supernatant 10 min. at 34,850g
Fraction 2
sediment 2 washings 9‰ NaCl 2 × 10 min. at 34,850g
supernatant (discarded)
Fraction 3

Fig. 2

culture was submitted to vigorous shaking for 30 min., after which it was maintained for 24 hr. at 37° C. Such cultures can easily be transplanted continuously in liquid hypertonic subculture as a normal bacterial suspension. Fig. 1 shows the increase of dry substance plotted against time for one of our cultures suspended in a hypertonic medium, and for a Tulasne culture (films)[2]. The phase of rapid growth in our culture occurs between 18 and 48 hr., whereas in the film cultures the growth takes much longer and reaches its maximum on the fifth day. As regards the morphological aspect, our cultures in hypertonic liquid medium contained large, swollen bodies, 8–12μ in size, as well as small and elementary bodies described by many authors. We have not been able to ascertain the presence of large bodies (20μ) which existed in the original cultures.

The different morphological forms of our cultures were separated by differential centrifugation followed by washings with 0·3 *M* saccharose solution (except where washing with 9 per mille sodium chloride is specified—Fig. 2). The respiration of the different fractions was studied in a Krebs medium with a Warburg apparatus, and the values have been referred to deoxyribonucleic acid (Fig. 3).

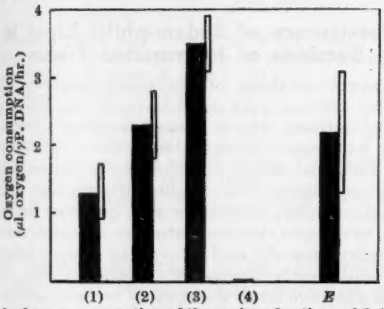

Fig. 3. Oxygen consumption of the various fractions of L forms. Values for large bodies (1), medium bodies (2), small bodies (3), elementary bodies (4) and total culture (*E*)

The results lead us to think that the small bodies of fraction 3, the metabolism of which seems to be most intense, correspond to a state of active proliferation. It appeared also that the oxygen consumption referred to deoxyribonucleic acid was practically nil for fraction 4 (elementary body). It seems to have lost its enzymatic apparatus for the aerobic degradation of glucose.

Supposing that the L forms are representative of a transition from one state to another—that of viruses—the elementary bodies would form a preliminary stage characterized by an already considerable reduction of the enzymatic apparatus of these micro-organisms.

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BIOLOGY

Changes in Lymphocytes during Antibody Production

During the course of an investigation[1] into the function and life-cycle of lymphocytes, a number of physical techniques were employed to determine the identity of cells isolated from various sources, for example, lymph glands, thoracic duct, thymus, spleen, blood, etc. The average cytoplasmic refractive index of small lymphocytes obtained from the above sites had been determined with a fair degree of certainty. It was noted that in chronically infected rats (rat pneumonia) the small lymphocytes, whatever their source, showed a significantly raised cytoplasmic refractive index. The subcutaneous injection of a particulate antigen (T.A.B.) produced a similar rise preceding but paralleling the rise in the antibody titre of the serum and thoracic duct lymph. We suggest that the refractive index change in the cytoplasm of the small lymphocyte is due to increased protein concentration connected with the mechanism of production of antibodies. A detailed study of this phenomenon is in progress.

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Zone Electrophoresis of Rous Sarcoma Virus

The value of zone electrophoresis in the study of animal viruses has been demonstrated by previous workers[1,2]. By this method new criteria for the classification of animal viruses can be obtained. In addition, the study of electrophoretic inhomogeneity of viruses is of special interest. Thus it could be shown for polivirus type I that the virus activity is shared by at least two components with different electrophoretic mobilities[2].

Zone electrophoresis might also be of value for the purification of viruses. In this report, preliminary results of electrophoresis of a cancer virus are given.

The supernatant of Rous sarcoma tissue cultures was chosen as a source of virus. Chicken tissue cultures were infected with Rous sarcoma virus and passaged serially by trypsinization for about two months until almost all cells showed the characteristics of Rous sarcoma cells and the titre of Rous virus in the supernatant was at least 5 log plaque-forming units per ml. The supernatants were then collected and treated by two cycles of centrifugation, one for 10 min. at 5,500*g* and a second for 60 min. at 54,000*g*. In some experiments, hyaluronidase in a final concentration of 7 units/ml. and trypsin in a final concentration of 0·025 per cent were allowed to act on the supernatant for 20 min. at 37° C. before centrifugation. The final pellet was taken up in 0·3 ml. veronal buffer *p*H 8·2 and mixed with an equal amount of 25 per cent cane sugar solution in buffer before introduction into the electrophoresis column. A detailed description of the electrophoresis apparatus and of the electrophoresis technique is given in previous papers[1,2]. Veronal buffer of *p*H 8·2 containing 47·6 gm. sodium diethylbarbiturate and 11·5 ml. *N*/6 hydrochloric acid in 4·3 l. of distilled water was used. Electrophoresis was allowed to proceed at room temperature for 3 hr., with a voltage gradient of 3·5 V./cm. and a current of 20 amp.

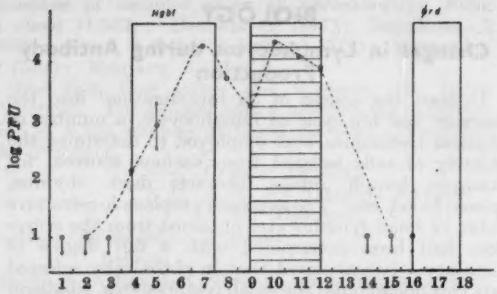

Fig. 1. Zone electrophoresis diagram showing the distribution of Rous sarcoma virus activity in log plaque-forming units (*PFU*) for each consecutive electrophoretic fraction of 0·8 ml. each, indicated on the abscissa. The position of the reference substances are indicated by the first and third vertical column and the opalescent zone containing the impurities by the second vertical column

In the first experiments, rabbit hæmoglobin and phenol red were added as reference substances. In some experiments, decomplemented and defatted[1] horse serum to a final concentration of 0·2 per cent was added to the sugar gradient to stabilize virus activity. The content of electrophoresis column was run out by taking samples of 0·8 ml. each. The virus activity of each fraction was assayed on the chorio-allantoic membrane of the chick embryo by the pock-count method, using 10 eggs per fraction[3].

The migration of the white opalescent initial zone containing a great deal of impurities as judged by electron microscopic analysis[4] could easily be followed against a dark background during electrophoresis. After an electrophoresis of 3 hr., this slightly broadened zone was apparently still compact, the lower part being still white opalescent with a sharp inferior border, whereas the upper part appeared slightly bluish. As can be seen from Figs. 1 and 2, this zone assumes a position intermediate between that of the rabbit hæmoglobin and phenol red under the conditions of the experiment at *p*H 8·2. From the same diagrams, it can be seen that a first peak, representing about 30–50 per cent of the virus activity, separated completely from the principal opalescent zone and migrated slightly faster than rabbit hæmoglobin at *p*H 8·2. As the same finding has been made in similar experiments in which no hæmoglobin was used as reference substance, it must be concluded that the mobility of the first peak of virus activity is independent of the presence of hæmoglobin.

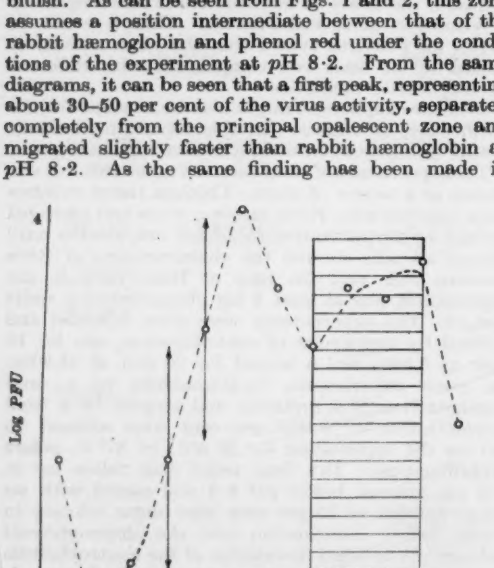

Fig. 2. Zone electrophoresis diagram of Rous sarcoma virus without reference substances. The vertical column represents the opalescent zone. The vertical arrows represent the confidence intervals. *PFU*, plaque-forming units

A second peak of virus activity was confined to the opalescent zone. Only by a further development of the electrophoresis at a low temperature and over a period of more than 3 hr., can it be established whether the virus activity found in this zone can be further separated from the bulk of impurities.

A third, minor peak of virus activity, with a higher mobility than the principal opalescent zone, was found only in some experiments, not discussed in this communication, and will be the subject of further analysis.

Experiments are now under way to establish the significance of the findings in relation to the possible electrophoretic inhomogeneity of Rous sarcoma virus as well as to its purification.

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Persistence of Sudanophilic Lipid in Sections of Mummified Tissue

Paraffin sections of Egyptian mummy tissues made by various workers[1–4] have shown the appearances of adipose tissue; examinations of mummy tissues by frozen section have been infrequent[3,5]. Shaw[3] failed to detect fat globules in frozen sections of adipose tissue from eighteenth-dynasty canopic material, namely, mesentery and gall-bladder serosa. Lipids have been demonstrated by chemical methods in mummy tissue[6,7] and proved to consist largely of fatty acids with traces of unaltered fat. These fatty acids have been thought to be derived not only from neutral fat but also from protein during the embalming process. Fatty acids and cholesterol have also been demonstrated by chemical methods in remnants of mummy brain[8].

While preparing an Egyptian mummy head for histological examination, it was noted that whitish-yellow material had persisted in the subcutaneous tissues, especially of the scalp, and in the marrow spaces of the calvarium. Frozen-sections of the scalp of the occipital region showed sudanophilia of the subcutaneous and subaponeurotic tissue with a light orange-red colour to a mixture of sudan III and IV and an intense black colour to sudan black. The material was obviously crystalline and proved largely to be plainly birefringent in bundles of thin acicular crystals on examination with polarized light. No red coloration was obtained with nile blue sulphate, and Von Kossa's stain for calcium showed moderate blackening confined strictly to the lipid areas. Sudanophilia and birefringence were reduced after treatment with ethyl alcohol, acetone and more markedly with chloroform and ether. Sudanophilic material which was not anisotropic was noted in small quantities in the remains of sebaceous glands and in small cutaneous nerves, presumably derived from myelin breakdown.

It is known that neutral fats and fatty acids, although mono-refringent in the fresh states, become crystalline on cooling or after fixation in formalin. This phenomenon is frequently seen on storage of animal tissues in formalin and is sometimes very obvious in old museum specimens.

Hunt[9] has described the appearances of the subcutaneous fat in female human bodies remaining in cool, dry surroundings with some air movement in which they would have eventually become naturally mummified. In one body, dead for 50–70 days, the subcutaneous fat spaces contained much granular material which did not dissolve in the usual fat solvents and stained only slightly with sudan black. In the superficial fat were collections of narrow pointed crystal spaces, thought to represent fatty acids. In a further body, dead for about 100 days, fat cells were mostly broken up and replaced by granular material and scanty crystal spaces.

The better preservation of lipid, its crystalline nature and association with calcium in the mummified scalp tissue suggests that some process other than simple dehydration had played a part. It may be that the alkalis used in mummification in Egypt produced some degree of hydrolysis of the neutral fats to fatty acids associated with calcium in the subcutaneous tissues.

My thanks are due to Mr. D. McSeveney for technical assistance.

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In vitro Cultivation of the Histotrophic Stages of *Haemonchus contortus* and *Ostertagia* spp.

Lapage[1] working with *Haemonchus contortus* reported in 1933 that: "Attempts have been made to cultivate the parasitic larval stages, a method having been found by which the free-living infective third stages may be exsheathed and sterilized, so that the first parasitic stages may be obtained and studied further in sterile media of known composition. Although these first parasitic stages have been studied in hanging drops in more than 200 media designed to imitate environmental factors to which parasites are presumably exposed in the body of the host no success has been obtained".

Stoll[2] found that exsheathed sterile *H. contortus* infective larvæ underwent the first parasitic ecdysis when maintained in various balanced salt solutions. Apart from the formation of a buccal cavity, no growth or differentiation occurred and the larvæ died soon after ecdysis occurred.

Weinstein and Jones[3] were the first to culture successfully *in vitro* the histotrophic stages of a parasitic worm, and in fact produced sexually mature adults of *Nippostrongylus muris*. Attempts by these workers to culture the parasitic stages of *Strongyloides* spp. were not successful, even in media in which *N. muris* had developed to adults[4].

In this department early attempts failed to culture *H. contortus* and *Ostertagia* spp. parasitic stages in the medium described by Weinstein and Jones. As a result, a programme was undertaken systematically to test, separately and in combination, the various nutrients which previous workers had found to support *in vitro* growth of nematodes. The components included chick embryo extracts, Hela cell cultures, various liver extracts, sodium caseinate, casein hydrolysates, serum, Tyrode solutions and various balanced salt solutions used in tissue culture methods. Various static and roller tube culture methods were tested, most media being set up under both conditions. The effect of transfering media on successive days was also investigated.

Success was eventually obtained with a medium, now in regular use, consisting of chick embryo extract, autoclaved sheep liver extract, casein hydrolysate and sheep serum in a 2 : 2 : 2 : 1 ratio. This is remarkably similar to the medium recommended by Weinstein and Jones, but differs in the mode of preparation of the liver extract. In this medium, using a roller tube technique, growth and metamorphosis of larval stages occurs up to the adult stage in about 24–30 days. By this time, however, the individuals have become recognizably stunted. The media require changing every 72 hr. for the first 12 days.

Re-investigation of the cause of the early failure suggests that the original fresh liver extract contained a lethal factor, and it appears that the nutrient factors in fresh liver are subject to considerable variation. The method of liver preparation now in use is that described by Nicholas[5], with the difference that only a single sterilization by autoclave is made.

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Effect of Gibberellic Acid on Length and Number of Epidermal Cells in Petioles of Strawberry

Increase in height is perhaps the most widely observed effect of gibberellic acid on plants. This is mainly due to longer internodes, and not to a larger number of nodes. The increased length of an internode has been variously ascribed to increases in numbers of cells, increases in length of cells and to both. Stowe and Yamaki[1], reviewing earlier (especially Japanese) work, conclude that "cell elongation in most cases seems to predominate as the result of gibberellin application". Since then Greulach and Haesloop[2] could find no significant increase in size of cell when the lengths of internodes of *Phaseolus vulgaris* were increased by a mean of 2·28-fold by the application of gibberellic acid. They concluded that cell division had been promoted. Further information is clearly desirable. In the strawberry plant, height is determined mainly by the length of the leaf petioles. The results presented in this communication show that increases in length of petiole brought about by the application of gibberellic acid involve increases both in the number and the length of cells in the epidermis.

Plants of the variety Redgauntlet were grown in pots in two growth cabinets at 60° F. in a 12-hr. photoperiod. The cabinets were illuminated at two different intensities (about 800 and about 1,200 foot candles) with equal numbers of 'Warm White' and

Table 1

Treatments and treatment differences	Length of petiole (mm.)	Mean length of cell (μ)	Calculated No. of cells
High light intensity	165·6	111·8	1,472
High light + G.A.	224·6	132·0	1,695
Increase due to G.A.	59·0	20·2	223
S.E.D.	±20·5	±7·6	±102·7
Increase due to G.A. (per cent)	35·6	18·1	15·1
Low light intensity	231·0	129·6	1,782
Low light + G.A.	261·8	138·6	1,892
Increase due to G.A.	30·8	9·0	110
S.E.D.	±20·5	±7·6	±102·7
Increase due to G.A. (per cent)	13·3	6·9	6·2
Overall mean increase due to G.A.	44·9	14·6	166·5
S.E.D.	±14·5	±5·4	±72·6
Increase due to G.A. (per cent)	22·7	12·1	10·2

G.A., gibberellic acid.

'Northlight' fluorescent lamps supplemented with tungsten filament lamps. Following an initial application of 16 µgm. per plant on June 18, gibberellic acid was applied in aqueous solution at the rate of 8 µgm. per plant twice weekly until August 12. The solution was applied in single drops of 0·1 ml. which were immediately covered with cover slips. The drops were absorbed in about 24 hr. It is possible that some loss of activity occurred during this period. This level of treatment gave the moderate increases in length of petiole thought to be desirable for this investigation and avoided gross morphological changes such as can be obtained with larger doses. There were five treated and five untreated plants in each growth cabinet.

On August 14 the petioles were measured from the point of insertion of the stipulary leaf bases to the conjunction of the laminæ. The second leaf to emerge on each plant after the commencement of treatment was selected for cell measurement. Leaves in this position on the stem were fully extended and also showed a substantial effect of treatment. The petioles were preserved in 50 per cent alcohol. For cell counts the petioles were removed from the alcohol and soaked in water over-night. Narrow strips of epidermis were peeled away from nine separate, equally spaced locations on each petiole. After clearing in lactic acid the strips were mounted in glycerine and inspected under the microscope. The image was projected on to a ground-glass screen for cell measurement. The cells were measured in tandem pairs, five pairs being measured at random in six different fields for each of the nine locations, making a total of 540 cells measured on each petiole. Guard-cell areas were deliberately avoided. Mean length of cell was obtained for each petiole, and this, divided into the length of petiole, gave a figure for 'number of cells' for each petiole.

Lengths of petioles, mean lengths of cells and the calculated figures for 'number of cells' were statistically analysed and the standard errors are tabulated together with the results. Percentage increases were calculated separately for length of petiole and the two component factors.

Significant differences between treated and untreated plants were obtained at the higher light intensity. At the lower intensity the differences were about half those at the higher, and were not significant. The overall effect of gibberellic acid at the two light intensities was a significant increase in length of petiole, composed of a significant increase in both mean length of cell and mean calculated number of cells. The percentage figures suggest that the increase in length of petiole was contributed to more or less equally by increases in both components.

The lesser effect of gibberellic acid at the lower light intensity is noted; but, as this work forms part of a broader investigation into the effect of a number of environmental factors on length of cell and number as components of length of petiole, a discussion of this and of the effect of light intensity is held over for another occasion.

We wish to thank Dr. M. R. Sampford for advice on the statistical treatment of the data, Mr. J. Stewart and Miss Kamala Saggar for measuring the cells, and Plant Protection, Ltd., for supplying the gibberellic acid.

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Effect of Residual House Spraying in the Plains on Anopheline Densities in Huts on the Pare Mountains

An experiment is in progress in the Pare area of Tanganyika to find whether or not malaria can be controlled by residual treatment of huts with dieldrin. The area is 3–4,000 square miles, involving a population of 100,000. The Pare Mountains extend along the length of the treated area, at an altitude of about 4,000 ft. above sea-level. The population is about equally divided between the malarious plains and the mountains, which are separated by a steep escarpment. Surveys of the human population did not suggest that active transmission occurred on the mountains[1]. Huts were treated only in the plains, and the first cycle of spraying was completed in November 1955. Subsequent treatments continue at intervals of 8 months.

The majority of the mountain population live at about 2,000 ft. above the plains; but villages occur on the sides of the mountain in a few areas where the escarpment is less steep. Spray catches were made in four villages above the escarpment, and in one village half way up it. Spray catches were also made at the foot of the mountain, in the area that was eventually treated with dieldrin. The results are shown in Table 1.

Above the escarpment, before residual spraying, there were very low densities of *A. gambiae* in huts and *A. funestus* compared with those at the foot of the mountain, but half-way up there was a substantial infestation of huts by *A. funestus* in May. After residual spraying, *A. funestus* disappeared from huts on the mountains as well as in the plains, and densities in huts of *A. gambiae* were also reduced.

These findings suggest that the presence of *A. gambiae* and *A. funestus* in huts on the mountains is dependent on direct infestation from the plains, followed to some extent also by seasonal reinfestation of breeding places, as *A. gambiae* was found breeding in a rice field on the mountains before residual spraying was carried out. Garnham[2] has discussed the factors that give rise to malaria transmission at high altitudes, and has shown how malaria, largely absent in the highlands of Kenya before the First

Table 1. DENSITIES OF *A. gambiae* AND *A. funestus* IN HUTS AT DIFFERENT LEVELS IN THE PARE DISTRICT

	Before dieldrin					After dieldrin								
	1955					1956					1957			
	Jan.	April	May	July	Oct.	Jan.	April	May	July	Oct.	Jan.	April	May	July	Oct.
Untreated huts 2,000 ft. above valley (20–24 huts)															
A. gambiae	0·3	0·6	0·2	0	0	0·2	0·2	0	0	0	0·5	0	0	0	0
A. funestus	0·1	0·1	1·9	0·5	0·7	0	0	0·05	0	0	0	0	0	0	0
Untreated huts 1,000 ft. above valley (5–6 huts)															
A. gambiae	0	5·0	0·3	0	0	0·7	0·2	0	0	0	0·8	0	0	0	0
A. funestus	0	3·2	39·5	8·5	0	0·2	0	0	0	0	0	0	0	0	0
Treated huts at foot of escarpment (8–24 huts)															
A. gambiae	35	13	19	2	2	3·0	2·2	0·1	0	0·13	2·0	0·5	0·1	0·75	0
A. funestus	2	24	75	28	2	0·1	0	0	0	0	0	0	0	0	0

World War, and the development of roads and agriculture, have increased concurrently. On the Pare Mountains, roads are relatively undeveloped, and motor transport is, and was, virtually absent in this area. It is probably the strong winds, blowing up from the Mkomazi valley, that are chiefly responsible for carrying the mosquitoes into the mountains. Mosquito densities in huts suggest that some transmission was occurring in a few villages on the upper slopes of the Pare Mountains before huts in the plains were treated with dieldrin, although little or none occurred above the escarpment. Residual spraying in the plains greatly reduced anopheline infestation in huts on the mountains, and has therefore indirectly protected the inhabitants from the risk of malaria infection.

I am indebted to Mr. J. D. Phipps for his help during the three years of observations, and to Dr. D. Bagster Wilson for valuable criticism.

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Paper Electrophoretic Separation of the Proteins of Some Leguminous Seeds

THE plant materials examined during this work were acetone powders prepared from lentils (*Lens esculenta*, Moench), 'horse' beans (*Vicia faba*, L.), lupin seeds (*Lupinus termis*, Forsk) and fenugreek seeds (*Trigonella foenum-graecum*, L.). Each acetone powder was extracted separately with 0·1 *N* borax–phthalate buffer at *p*H 8·0, the proportion being 10 gm. of acetone powder to 60 ml. of buffer. Extracts obtained in this way were subjected to paper electrophoresis on Whatman No. 1 filter paper in a Shandon horizontal tank. Borax–phthalate buffer, which was prepared by mixing 0·1 *N* borax and 0·1 *N* potassium hydrogen phthalate (*p*H 8·0), was used. A potential of 150 V. was applied for 12 hr. The protein bands were dyed with azocarmine *B* solution according to Turba and Enenkel's method[3].

Four coloured bands (designated *A–D*) appeared in the electrophoretic pattern of each of the seed extracts. It was possible, by the use of ammonium sulphate fractionation, to isolate each of the proteins *B*, *C*, and *D* from the extract of lentil seed. Each of the protein fractions was re-precipitated 2–3 times and each of the final precipitates was dissolved in a small volume of borax–phthalate buffer and dialysed against the same buffer. These protein fractions were tested electrophoretically along with a sample of the original extract.

Protein fraction *D* (precipitated in the range 45–54 per cent saturated ammonium sulphate) was orange-red in colour and fluorescent in ultra-violet light. The absorption spectrum was read with a Hilger spectrophotometer and showed maxima at 360, 460 and 550 mμ (Fig. 1), which indicates that this protein is a flavoprotein.

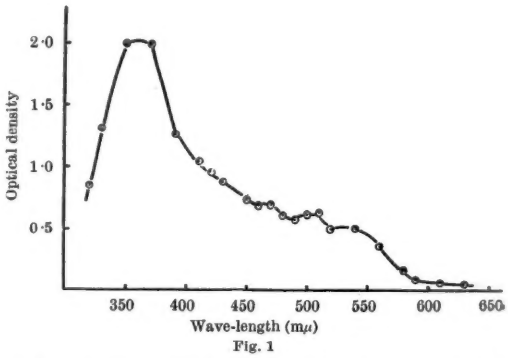

Fig. 1

In order to determine the percentage of each of the protein constituents the filter paper was cut (in a direction perpendicular to the flow of the current) into strips 0·5 cm. wide. Each of the small strips was eluted separately with 5 ml. 10 per cent ammonium hydroxide. The optical density of each extract was determined with a Unicam colorimeter using a filter (Ilford No. 303). By plotting optical density reading against the distance from the point of application of the protein extract to the strip an electrophoretic pattern was obtained. By means of a planimeter, the area under each peak was measured, and in this manner the percentage of the different proteins (in relation to the total proteins in the extract) was assessed. The results (Table 1) indicate that, although the extract of each of the four kinds of seeds under investigation contains the four fractions, the percentage of each of the proteins varies according to the type of seed.

Table 1. AMOUNTS OF VARIOUS PROTEINS IN SOME LEGUMINOUS SEEDS

Seed	Protein			
	A	*B*	*C*	*D*
Lupinus termis	1·89	86·55	8·79	2·75
Trigonella foenum-graecum	5·26	84·27	5·26	5·26
Vicia faba	5·11	46·51	40·23	8·13
Lens esculenta	3·91	71·02	7·57	17·49

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Density-Dependent Factors in Ecology

Solomon and Varley[1] did well to direct attention to the confusion that accompanies the ecological term 'density-dependent factors'. Howard and Fiske's[2] original idea that the multiplication of natural populations of animals can be restricted only by some "factor" that exerts "a restraining influence which is relatively more effective when other conditions favour undue increase" has been extended in a number of directions. I would like to add to Solomon and Varley's etymological criticism of the usage of the term my own criticism of the fruitfulness of the ideas implicit in the term.

It has been argued that only 'biotic factors' can qualify for the class 'density-dependent factors' and hence only competition can limit the numbers of natural populations. Howard and Fiske[2] and Smith[3] qualified this argument but Nicholson[4], and Elton and Miller[5] were more specific. When I tried to confirm the statement by examining the case-histories of a number of populations the ecology of which had been described, I found that there was little correlation between biotic factors and density-dependent factors[6]. The concept of density-dependent factors has also been used as a starting point for mathematical models. The well-known models of Lotka[7] and Volterra[8] have been partly confirmed by laboratory experiments with such simple animals as *Paramecium* but not with more complex ones such as *Calandra* and *Tribolium* and not with any sort of animal in Nature[9].

Nicholson[10] has published an elaborate mathematical treatment that purports to cover natural populations. His model rests upon the idea of 'equilibrium density' which is analogous to the concept of the 'singular point' in the Lotka–Volterra models. For example, his equation for intraspecific competition, which is one of three basic equations that form the foundation for his model, reads :

$$N_E = \frac{g - lg - wg}{q}$$

where g is the rate of replacement of the 'governing requisite', l is the proportion lost to extraneous influences, w is the proportion lost to individuals that fail to complete the life-cycle through crowding, q is the amount required by one individual to complete its life-cycle and N_E is the equilibrium density.

The value of w depends on the density of the population ; above a certain ceiling of density w may be 1 ; below a certain threshold it may be 0. Solving the equation for values of w between 1 and 0 gives values of N_E between 0 and $\frac{g - lg}{q}$. This does not satisfy the concept of an equilibrium density. On the other hand the equation may be written :

$$N = \frac{g - lg - wg}{q}$$

where N is defined as the density of the population. Then a particular value of N, say N_E, may be designated such that it corresponds to an arbitrary value of w, say w'. But in Nicholson's model the value of w' is defined in terms of N : w' is the value of w which gives $N = N_E$ and there is no other way of defining it. Thus the equation is a tautology. The other two basic equations are subject to similar criticism.

Milne[11] and Nicholson[10,12] argued that only density-dependent factors can keep a population from becoming extinct because as Elton[13] put it, "the control of populations, i.e., the ultimate upper and lower limits set to increase, is brought about by density-dependent factors". Now if we do an experiment to test a particular null hypothesis such as "this population of species x will not be extinguished by n hours exposure to $t°$ C" we may consider that the negative hypothesis has been disproved if the population is observed to be extinct after we have treated it in this way. (See Fisher's[14] discussion of the null hypothesis.) But if the population remain extant after the experiment we cannot reasonably argue that the population was kept extant by exposure to $t°$ C. for n hours ; similarly, with all other environmental components, including density-dependent factors. Moreover, because the argument that only density-dependent factors can keep a population extant depends on the concept of 'ultimate limits' it is not possible to specify a definite time in the null hypothesis that stems from this proposition ; this implies that experiments must be continued indefinitely if the null hypothesis is to be disproved[6]. For these two reasons this argument has stultified experiment.

In science an idea may be judged fruitful if it leads to experiment and observation which extend our understanding of Nature. By this criterion the idea of 'density-dependent factors', like the idea of vitalism, seems to have been remarkably fruitless.

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Preparation and Sectioning of Tissues embedded in 'Araldite' for Electron Microscope Examination

Owing to the complete lack of polymerization damage and less-stringent hardening conditions, 'Araldite' is being increasingly used as an alternative to butyl methacrylate as an embedding medium in the preparation of tissue for study in the electron microscope. Unfortunately, it has one serious drawback of its own. Unless the consistency of the plastic falls within fairly narrow limits, serious wrinkling is found on sectioning which may make the specimens quite unsuitable for study.

The 'Araldite' components used in the embedding mixture are : 'Araldite' casting resin *M*, 'Araldite'

hardener 964*B*, and 'Araldite' accelerator 964*C*. Dibutyl phthalate is used as a plasticizing agent.

Originally a mixture of casting resin 10·0 ml., hardener 10·0 ml. and plasticizer was used for the initial shakings after fixation in osmic acid and dehydration in alcohol. Soaking times at 48° C. were 3 hr. in a mixture of ½ absolute alcohol, ½ 'Araldite', followed by three soakings of 3 hr. each in 'Araldite' alone. 0·4 ml. accelerator was then added to the mixture and the tissue was left to soak at room temperature for 12 hr. before the final embedding at 48° C. in accelerated 'Araldite'. The capsules were hardened at 48° C. for about 72 hr. before cutting.

It was early found that even a moderate increase in the concentration of accelerator produced a very hard and brittle block. It was possible to produce thin sections from such a block, but they invariably showed severe wrinkling, and it is now usual to discard any blocks which are found to be brittle during preliminary trimming. Reduction of accelerator produced plastic of a consistency that would cut without wrinkling, but this only applied to the supporting block. The tissue itself was often exceedingly soft and pasty, and it was obvious that the 'Araldite' had not penetrated in desirable concentrations. As it was known that the tissue could be hardened by additional accelerator it was suspected that the casting resin rather than the hardener was failing to penetrate, and this view was supported by the fact that the hardener is by far the less viscous of the two. As a result the soaking times were greatly prolonged, and the concentration of the casting resin in the early mixtures was increased. The concentrations used in the first soakings are now: casting resin 15 ml., hardener 5 ml., plasticizer 1 ml. After fixing and dehydration the tissue is soaked at 48° C. in a mixture of ½ absolute alcohol, ½ 'Araldite' for 6 hr., and then in pure 'Araldite' for 72 hr., the mixture being changed every 24 hr. The soaking is then continued for another 72 hr. in a mixture of casting resin 10 ml., hardener 10 ml. and plasticizer 1 ml., the resin again being changed every 24 hr. 0·3 ml. accelerator is then added for a 24 hr. soak at room temperature followed by the final embedding in a fresh accelerated mixture. With only 0·3 ml. accelerator hardening times at 48° C. are increased, and it is not unusual for the blocks to require baking for a week before they are suitably hard. Even now preliminary trimming may show the tissue to be undesirably soft, but further baking of the untrimmed capsules produces little improvement. If, however, the block is trimmed to expose the tissue in a small pyramid of soft plastic, further baking at 48° C. for 2–3 days will cause satisfactory hardening to a cutable consistency.

This embedding procedure has been successfully used on a variety of tissues, including pituitary, liver, various tumours, and striated muscle; but even now it is rare to produce sections without a trace of wrinkling. Birbeck and Mercer[1] found that a narrow knife angle and very slow passage of the block across the blade would reduce wrinkling, as would the reduction of the cutting area of the block to very small dimensions. This has also been our finding, but with 'Araldite' it is often possible to obtain thin sections of up to 1 mm. square, and the increase in viewable tissue area is a great advantage. In these conditions, it is usually found that the portions of the section cut last show wrinkling, but this can largely be counteracted by trimming the block to rectangular shape and cutting with one long side to the blade.

During the period of this work I was in receipt of a grant from the British Empire Cancer Campaign.

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A Simple Micro-Stirrer

A simple micro-stirrer has been developed for micro-analyses involving quantities of fluid varying from 1 ml. down to small drops of fluid which are titrated on waxed slides. Its main advantages over previous methods of micro-stirring are that it is cheap and relatively simple to make and can be controlled to give almost instantaneous even mixing without splashing or bubbling. It is therefore particularly suitable for continuous stirring while performing potentiometric or colorimetric titrations.

The stirrer (Fig. 1) consists of an electric bell assembly driven by means of a small domestic bell transformer which is tapped to give 3, 5 and 8 volts. For potentiometric titrations the bell is removed and a piece of stiff piano wire is attached to the hammer arm by means of a tight-fitting polyethylene sleeve. The piano wire is flattened at the sleeve end to prevent it turning and is then bent downwards through an angle of 90°. A piece of 'Tufnol' insulates the wire from the bell mechanism. The other end of the piano wire carries a small chuck, which holds a paddle-shaped electrode.

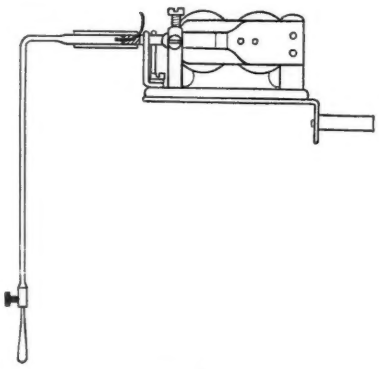

Fig. 1

Even and splashless stirring is obtained by limiting the travel of the hammer arm by means of two movable stops, one on each side of the arm. The high-frequency vibrations are transmitted and amplified by the whip of the stirring arm, the lateral vibrations of which should be very small to obtain the desired type of stirring. The amplitude of these vibrations is controlled by the length and stiffness of the wire, while their frequency can be altered by varying both the voltage energizing the bell and the setting of the interruptor set screw. For colorimetric titrations, particularly those carried out in an absorptiometer, a small glass paddle is recommended.

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Salt Excretion in Marine Birds

May I add a further observation to F. S. Russell's interesting communication under this title[1]? More than thirty years ago I noticed a similar thing in the giant petrel or stinker (*Macronectes giganteus*) of the southern oceans, and published[2] an account of it, though not in a scientific paper, in 1951: "When [a flying stinker] is right alongside and you can see him plainly, nearly always you will notice that he has a drop on his nose; hanging from the tip of the hook at the end of his beak is a drop of something—whether water or some other fluid I know not". This, too, was evidently salt excretion in action.

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PSYCHOLOGY

Colour Vision Phenomenon of a New Class

If one looks toward a bright field of white light (white cloud or white fluorescent lamp), interposes an orange Wratten No. 21 filter for 5 sec., then removes the filter, a bright, saturated greenish-yellow pattern is seen. It is of irregular, blotchy shape and persists for 1–2 sec.

The hue and saturation of the pattern remain unchanged despite wide variation in choice of filter used in step 1. (Step 1 is the 5-sec. period in which an orange filter or the equivalent is used; step 2 is the 1–2-sec. period in which the pattern is seen.) Instead of the orange Wratten 21 filter, any filter that transmits much 540–590 mμ light and no light of wave-length below 490 mμ may be used.

In step 2, instead of using no filter, any blue, green, yellow, orange, purple or grey filter that has appreciable transmittance near 470 mμ may be interposed.

To predict whether a filter will succeed in step 1, the spectral transmittance curve of the filter must be examined. The colour of the filter may not be indicative. (I have a pair of orange filters that are almost identical in colour but behave oppositely, one succeeding in step 1 and the other in step 2.)

Moderately high intensity is required in step 1. The intensity of a white cloud or a bare white fluorescent lamp is very satisfactory. A heavily overcast sky, or a sheet of white paper resting on the top of a desk, may be too dim.

The intensity and quality of the step 1 illumination determine whether the pattern will be seen (in the subsequent step), but do not govern the brightness or colour of the pattern.

It is the step 2 illumination that governs the brightness and colour of the pattern. If the step 2 illumination consists of white light, the pattern appears greenish-yellow, and the brightness is roughly proportional to the intensity of the white light. If the step 2 illumination consists of just 400–500 mμ light, the pattern appears green. If the step 2 illumination contains 400–500 mμ light and also light in longer wave-length bands, the hue appears intermediate between green and the hue one normally associates with the longer wave-length bands. For example, the illumination obtained with the aid of a white fluorescent lamp and a reddish-purple filter transmitting in the two bands 400–500 mμ and 600–700 mμ leads to a pattern that is midway between green and red, namely, orange.

If the step 2 illumination is of zero intensity, the pattern does not appear. (Various after-images appear, but seem unrelated to the pattern under discussion.)

The pattern has an irregular, blotchy shape, and very different shapes may be noticed in successive trials. The size of the pattern may decrease markedly from one trial to the next, and, after four or five trials made within a period of one minute, the pattern may entirely fail to appear. In the first trial the pattern may have an angular width of 40–80 deg., and the fovea and macula regions may participate; in subsequent trials the pattern becomes less extensive, and the fovea and macula regions may fail to participate. The grain size, or resolution, of the pattern is low, being perhaps 0·1–0·5 deg.

After resting his eye for 10 min. the observer may see the phenomenon again. Resting does not require dim light or darkness; it requires merely the avoidance of light that is devoid of energy in the 400–500 mμ range. Looking through any step 1 filter is tiring, but looking through any step 2 filter is not. Thus tiring, too, depends on the transmittance curve of the filter rather than on its colour.

In the first trial (that is, when the eye is fresh), the duration of step 1 may be reduced; the 5-sec. duration is not necessary, and durations as short as 2 sec. (sometimes even ½ sec.) suffice. Moreover, the intensity of the pattern afterwards seen is independent of the step 1 duration.

When the pattern disappears (after 1–2 sec. of step 2 illumination), it does not fade gradually and uniformly, but disappears piecemeal, each piece disappearing suddenly.

Each eye acts independently. One eye may become tired and the other (not exposed to step 1 illumination) may remain fresh. Indeed, the different regions of a single eye appear to act independently. Accordingly, split-field experiments are feasible. For example, in step 2 the patterns produced by two unlike filters held side-by-side a few inches in front of the eye may be compared.

A blue or magenta pattern is sometimes observed in step 1 if this step is prolonged for 5–15 sec., and this pattern sometimes has a shape similar to that of the pattern afterwards appearing in step 2. (I am indebted to my colleague E. S. Emerson for pointing this out.)

Approximately fifty of my friends have tried to see the greenish-yellow pattern by the method indicated in the first paragraph, and more than forty succeeded.

The new phenomenon has little in common with the usual adaptation, fatigue, or complementarity phenomena. Such phenomena usually involve smooth fields, dim and unsaturated colour, slow build-up and gradual fading. Also, the hues perceived usually change when the hues of any of the exciting fields are changed, and they are similar when exciting fields are similar in colour. The new phenomenon exhibits very different tendencies which are suggestive of abrupt switching mechanisms.

William A. Shurcliff

Research Laboratory,
Polaroid Corporation,
Cambridge, Mass. Oct. 21.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, January 19

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Prof. A. L. Banks: "The Study of the Geography of Disease".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. A. H. W. Beck: "High-Current Density Thermionic Emitters".

UNIVERSITY OF LONDON INSTITUTE OF EDUCATION (in the Assembly Hall, Malet Street, London, W.C.1), at 5.30 p.m.—Dr. W. Mays: "Piaget's Theory of Intellectual Development".*

BRITISH COMPUTER SOCIETY (at the Northampton College of Advanced Technology, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. D. C. Hemy: "The Study of the Application of a Computer to Production Control".

INSTITUTE OF METAL FINISHING (at Northampton College of Advanced Technology, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. P. Eisler: "Printed Circuits—Some Metal Finishing Methods Used on Foil-Clad Laminates in Electronic Production".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at Enfield Technical College, Queensway, Ponders End, Enfield), at 7.30 p.m.—Dr. A. S. Curry: "The Chemistry of Poisoning".

Monday, January 19—Thursday, January 22

PHYSICAL SOCIETY (at the Royal Horticultural Society's Old and New Halls, Westminster, London, S.W.1)—Exhibition of Scientific Instruments and Apparatus.

Discourses:

Monday, January 19

At 5.45 p.m.—Mr. R. S. Pease: "The Physics of Controlled Thermonuclear Fusion".

Tuesday, January 20

At 5.45 p.m.—Dr. Robert Page: "Frontiers of Space".

Wednesday, January 21

At 5.45 p.m.—Mr. J. G. D. Pratt: "Physical Science in the Trans-Antarctic Expedition", introduced by Sir Vivian E. Fuchs.

Tuesday, January 20

BONE AND TOOTH SOCIETY (at the Institute of Orthopædics, 234 Great Portland Street, London, W.1), at 4.30 p.m.—Symposium on "Epiphysial Growth".

BRITISH MUSEUM (NATURAL HISTORY) (in the Chemistry Lecture Theatre, Imperial College of Science and Technology, Exhibition Road, London, S.W.7), at 5.30 p.m.—Dr. Isles Strachan: "Darwin and Palæontology" (Swiney Lectures on Geology).* (Further lectures on January 22, 27, 29, February 3 and 5.)

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "D.C. Amplifiers" opened by Mr. K. Kandiah.

BRITISH GLACIOLOGICAL SOCIETY (at Bedford College, Regent's Park, London, N.W.1), at 6 p.m.—Prof. R. Finsterwalder (Munich): "The International Glaciological Expedition to Greenland".

PLASTICS INSTITUTE, LONDON AND DISTRICT SECTION (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—Prof. M. G. Stacey, F.R.S.: "Fluorine Containing Polymers".

Wednesday, January 21

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—The Right Hon. Lord Nathan, P.C.: "Technical Education—a Prognosis".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. F. A. Berson: "Some Measurements on Undercutting Cold Air"; Mr. R. A. Hamilton: "The Meteorology of North Greenland During the Mid-Summer Period" and "The Meteorology of North Greenland During the Mid-Winter Period".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Mr. K. S. Lomax: "Production and Productivity Movements in the U.K. since 1900".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. C. G. Garton: "Dielectric Materials—Trends and Prospects".

INSTITUTION OF MECHANICAL ENGINEERS, APPLIED MECHANICS GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Trouble with Vibration".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (joint meeting with the LONDON SECTION of the SOCIETY OF CHEMICAL INDUSTRY, at University College, Gower Street, London, W.C.1), at 6.30 p.m.—Sir Eric Rideal, F.R.S.: "The Impact of Colloid Science on Technology".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (joint meeting with the OIL AND FATS GROUP, at Brunel College, Acton), at 7 p.m.—Prof. A. C. Frazer: "The Biological Effects of Polyoxyethylene Esters".

Thursday, January 22

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. B. C. Brookes: "The Limits of the Popularization of Science".*

UNIVERSITY COLLEGE, DEPARTMENT OF BIOCHEMISTRY (in the Physiology Theatre, Gower Street, London, W.C.1), at 5 p.m.—Prof. F. G. Young, F.R.S.: "Hormones and Metabolic Processes".*. (Further lectures on January 29 and February 5).

Thursday, January 22—Friday, January 23

INSTITUTE OF PHYSICS (in collaboration with the BRITISH NUCLEAR ENERGY CONFERENCE, in the Lecture Theatre of the Institution of Civil Engineers, Great George Street, London, S.W.1), at 2.30 p.m. on Thursday and 9.30 a.m. on Friday—Symposium on "Nuclear Fuel Cycles".

Friday, January 23

BRITISH PSYCHOLOGICAL SOCIETY, OCCUPATIONAL PSYCHOLOGY SECTION (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. M. J. Kirton: "Some Aspects of Current Research on Management Initiative".

BIOCHEMICAL SOCIETY (in the Department of Chemistry and Biochemistry, St. Thomas's Hospital Medical School, London, S.E.1), at 2 p.m.—379th Meeting.

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 2.15 p.m.—Geophysical Discussion on "The Automatic Reduction of Geophysical Data". Chairman: Sir Edward Bullard, F.R.S. Speakers: Mr. G. A. Corby, Mr. A. Dennison, Mr. G. W. Lennon, Mr. R. H. Merson, Mr. C. M. Minnis and Mr. M. J. Tucker.*

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. H. R. Howells: "Marine Refrigeration" (Thomas Lowe Gray Lecture).

MANCHESTER STATISTICAL SOCIETY, INDUSTRIAL GROUP (in the Portico Library, 57 Mosley Street, Manchester), at 6 p.m.—Dr. M. G. Simpson: "Operational Research in the Coal Industry".

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Inaugural Meeting of the Institution's Medical Electronics Group. Address by Prof. A. V. Hill, F.R.S.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

KEEPER (with a university degree or the Diploma of the Museums Association, specialized in some branch of zoology or botany, a wide general knowledge of natural history, and preferably experience of museum work) OF THE DEPARTMENT OF BIOLOGY—The Director, Museum and Art Gallery, New Walk, Leicester (January 31).

LECTURER IN BIOCHEMISTRY—The Secretary of University Court, The University, Glasgow (January 31).

RESEARCH ASSISTANT IN THE DEPARTMENT OF PHYSICS for post-graduate studies in electron diffraction and microscopy, leading if desired to a higher degree—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (January 31).

SENIOR LECTURER IN MECHANICAL ENGINEERING—The Registrar, The University, Sheffield (January 31).

SENIOR LECTURER (with a good honours degree and teaching experience) IN APPLIED MATHEMATICS, and LECTURERS (2) (with a good honours degree and teaching experience) IN MATHEMATICS at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (February 4).

SENIOR LECTURER or LECTURER (with special qualifications in pure mathematics) IN MATHEMATICS—The Registrar, The University, Manchester 13 (February 7).

CHAIR OF MICROBIOLOGY in the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 12).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY, ENGINEERING, PHARMACOLOGY or PHYSICS—The Secretary, The University Aberdeen (February 13).

SENIOR LECTURER IN OBSTETRICS AND GYNÆCOLOGY at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, February 15).

LECTURER (preferably interested and with research experience either in Western industrial societies or in Africa) IN ANTHROPOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 16).

LECTURER (with an honours degree in geography) IN GEOGRAPHY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 16).

SENIOR LECTURER IN THE HISTORY AND PHILOSOPHY OF SCIENCE at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 16).

HALLIBURTON CHAIR OF PHYSIOLOGY tenable at King's College—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 17).

LECTURER IN PHILOSOPHY at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 20).

DEMONSTRATOR (with interests in human geography, preferably economic geography) IN THE DEPARTMENT OF GEOGRAPHY—The Secretary of the Appointments Committee, Department of Geography, The University, Downing Place, Cambridge (February 21).

LECTURER IN APPLIED MATHEMATICS (DIGITAL COMPUTING)—The Secretary, The Queen's University, Belfast (February 28).

CHAIR OF VETERINARY MEDICINE or CHAIR OF VETERINARY SURGERY, in the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 9).

RESEARCH FELLOW or FELLOW IN THE DEPARTMENT OF STATISTICS, Research School of Social Sciences, Australian National University, Canberra, to work in the field of mathematical statistics and its applications to other sciences—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 16).

CHAIR OF PHILOSOPHY in the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, March 31).

SENIOR LECTURER IN PHYSICS at Victoria University of Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, March 31).

ASSISTANT PROFESSOR OF BIOLOGY, to give instruction in physiology, embryology and histology—The Head, Department of Biology, Memorial University of Newfoundland, St. John's, Newfoundland.

GRADUATE PHYSICISTS (with a first or good second) for research into either (*a*) the solution of scientific and technical problems by the use of all types of radioisotope techniques; or (*b*) the development of new measuring techniques for radioactive materials and ionizing radiations and the investigation of limits of performance of detectors—The Group Recruitment Officer (1270/34), United Kingdom Atomic Energy Authority, A.E.R.E., Harwell, Berks.

LABORATORY TECHNICIAN (male or female, with experience in biology and interested in animals)—The Secretary, Furzedown College, Welham Road, London, S.W.17.

LECTURER IN APPLIED PHYSICS, to assist in establishing Higher National Certificate courses in Applied Physics—The Principal, Farnborough Technical College, Boundary Road, Farnborough, Hants.

LECTURER (man or woman, with an honours degree in physics and preferably a teaching qualification) IN PHYSICS at the Medical School, Kano, Northern Nigeria, to teach to advanced level—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.117/408/030.

LECTURER (preferably with an active interest in research, together with teaching and/or industrial experience) TO TEACH PHYSICAL CHEMISTRY to the standard of the Diploma of Technology, B.Sc. (Special) Chemistry and A.R.I.C.—The Principal, College of Technology, Queen Street South, Huddersfield.

PRINCIPAL (preferably under 50, with a degree in engineering or applied science or professional equivalent, together with wide experience of technical education) of the recently established Institute of Technology, Jamaica—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.114/32/09.

PROFESSOR OF MECHANICAL ENGINEERING, and a LECTURER in ELECTRICAL ENGINEERING (ELECTRICAL POWER) at the University of Ceylon—The Ministry of Labour and National Service (E.9), 26–28 King Street, London, S.W.1, quoting E.9/TCS/216-7CEY.

SCIENTIFIC OFFICER (honours graduate, preferably in biochemistry or physiology), to work, both in laboratory and with experimental animals, on nutritional problems in pigs—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 59/1.

TECHNICIAN (preferably with previous experience) FOR THE CHEMISTRY LABORATORIES—The Secretary, Royal Holloway College (University of London), Englefield Green, Surrey.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Scientific Council for Africa South of the Sahara. Publication No. 32: Ninth Meeting of the Scientific Council, Accra, 1958. Pp. 173. (Published under the sponsorship of the Commission for Technical Co-operation in Africa South of the Sahara.) (London: Secretariat, C.C.T.A./C.S.A., 1958.) [1011

Building Research Station Digest, No. 115 (October 1958): Ready-Mixed Concrete. Simplified Daylight Tables. Pp. 4. (London: H.M. Stationery Office, 1958.) 3*d*. [1011

Bulletin of the British Museum (Natural History). Entomology. Vol. 7, No. 5: Revision du Genre *Exocentrus* Mulsant (Col., Cerambycidae). Par S. Breuning. Pp. 209–328. 40*s*. Vol. 7, No. 6: New and Little Known Emesinae (Reduviidae, Hemiptera) in the British Museum (Natural History), London. By P. Wygodzinsky. Pp. 329–346. 6*s*. Vol. 7, No. 7: New Species and Subspecies of Odonata, and On Some Trichoptera from S. Rhodesia and Portuguese East Africa. By D. E. Kimmins. Pp. 347–368. 7*s*. (London: British Museum (Natural History), 1958.) [1011

Department of Scientific and Industrial Research: Road Research Laboratory. Road Research Technical Paper No. 42: Reflex Reflectors. By Dr. K. N. Chandler and J. A. Reid. Pp. iv+30+4 plates. (London: H.M. Stationery Office, 1958.) 2*s*. 6*d*. net. [1011

British Standards Institution. British Standard for Anatomical, Physiological and Anthropometric Principles in the Design of Office Chairs and Tables. By Dr. W. F. Floyd and Dr. D. F. Roberts. Pp. 20. (B.S. 3044: 1958.) (London: British Standards Institution, 1958.) 5*s*. net. [1011

British Electrical and Allied Industries Research Association. Technical Report L/T 360: The Polymerization of Organic Compounds by Ionizing Radiation. By C. E. King. Pp. 7+4 figures. 7*s*. 6*d*. Technical Report L/T 364: The Effects of Small Discharges on Some Insulating Materials. 2: At Atmospheric and Reduced Pressures. By N. Parkman. Pp. 19+16 figures. 18*s*. (Leatherhead: British Electrical and Allied Industries Research Association, 1958.) [1011

Death Rates by Age and Sex for Tuberculosis and Selected Respiratory Diseases, England and Wales, 1911–1955. By R. A. M. Case and Joyce L. Harley. Pp. ix+20. (London: Chester Beatty Research Institute, Institute of Cancer Research, Royal Cancer Hospital, 1958.) [1011

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 989, Vol. 251 (6 November 1958): An Experimental Determination of the Fermi Surface in Lead. By A. V. Gold. Pp. 85–112+plate 1. 10*s*. 6*d*. No. 990, Vol. 251 (6 November 1958): The Polarization of Atomic Line Radiation Excited by Electron Impact. By I. C. Percival and M. J. Seaton. Pp. 113–138. 8*s*. (London: Royal Society, 1958.) [1011

Other Countries

State of California: Department of Fish and Game. Fish Bulletin No. 106: Age and Length Composition, Pacific Coast Catches, Sardines and Pacific Mackerel 1955–56 and 1956–57 Seasons; and the Northern Anchovy, 1954–55 through 1956–57 Seasons. Pp. 72. (Terminal Island, Calif.: Department of Fish and Game, 1958.) [1011

Proceedings of the United States National Museum. Vol. 108, No. 3400: A Revision of the Eels of the Genus *Conger* with Descriptions of Four New Species. By Robert H. Kanazawa. Pp. 219–267+4 plates. Vol. 108, No. 3401: Three North American Cretaceous Fishes. By David H. Dunkle. Pp. 269–277+3 plates. Vol. 108, No. 3402: Taxonomy and Nomenclature of Three Species of Lonchura (Aves: Estrildinae). By Kenneth C. Parkes. Pp. 279–293. Vol. 108, No. 3404: Advances in Our Knowledge of the Honey-Guides. By Herbert Friedmann. Pp. 309–320. (Washington, D.C.: Government Printing Office, 1958.) [1011

United States Department of Commerce: Coast and Geodetic Survey. Technical Bulletin No. 3 (May, 1958): Recent Increases in Coastal Water Temperature and Sea Level—California to Alaska. By H. B. Stewart, Jr., B. D. Zetler and C. B. Taylor. Pp. 11. (Washington, D.C.: Government Printing Office, 1958.) 20 cents. [1011

Tobacco Research Board of Rhodesia and Nyasaland. Bulletin No. 7: Barn Construction and Curing Procedure. Pp. 16+9 drawings. (Salisbury: Tobacco Research Board of Rhodesia and Nyasaland, 1958.) [1011

Annals of the New York Academy of Sciences. Vol. 72, Article 9: Lymphocytes and Plasmacytes in Nucleoprotein Metabolism. By Margaret A. Kelsall and Edward D. Crabb. Pp. 293–338. Vol. 72, Article 10: Quantum Aspects of Catalysis: Oxidations and Other Reactions of Ethylene. By Raymond R. Myers. Pp. 339–352. (New York: New York Academy of Sciences, 1958.) [1011

Northern Rhodesia: Geological Survey Department. Report No. 3: The Geology of the Kariba Area. By Dr. Brian Hitchon. Pp. vi+41+4 plates+4 maps. (Lusaka: Government Printer, 1958.) 30*s*. [1011

Canada: Department of Northern Affairs and National Resources. National Museum of Canada. Bulletin No. 151: Roundelays. Folk Dances and Games collected in Canada and New England, and prepared by Marius Barbeau. Piano arrangements by Maurice Blackburn. Interpreted in English by Joy Tranter. Illustrations by Marjorie Border. Cover by Grave Welvin. Pp. 104. 2.50 dollars. Bulletin No. 155: A Zoogeographical Study of the Amphibians and Reptiles of Eastern Canada. By J. Sherman Bleakney. Pp. iii+119 (49 maps). 2 dollars. (Ottawa: Queen's Printer, 1958.) [1011

Archives de l'Institut de Paleontologie Humaine, Paris. Mémoire 29: La Grottée de Fontéchevade. Deuxième partie: Anthropologie. Par Henri-V. Vallois. Troisième partie: Géologie et Paléontologie. Par H. Alimen, C. Arambourg et A. Schreuder, avec la collaboration de G. Henri-Martin, J. Berlioz et J. Bouchud. Pp. 262+6 planches. (Paris: Masson et Cie., 1958.) [1011

Smithsonian Institution. List of Smithsonian Publications Available for Distribution, June 30, 1958. Compiled by Eileen M. McCarthy. Pp. vi+54. (Publication 4344.) (Washington, D.C.: Smithsonian Institution, 1958.) [1011

Annual Report of the Board of Regents of the Smithsonian Institution Showing the Operations, Expenditures, and Condition of the Institution for the year ended June 30, 1957. Pp. x+499+74 plates. (Publication 4314.) (Washington, D.C.: Government Printing Office, 1958.) 4.50 dollars. [1011

Chicago Natural History Museum. Fieldiana: Zoology. Vol. 35, No. 6: Notes on African Bulbuls, Family Pycnonotidae—Class Aves. By Austin L. Rand. Pp. ii+145–220. (Chicago, Ill.: Chicago Natural History Museum, 1958.) 1.25 dollars. [1011

Annals of the New York Academy of Sciences. Vol. 73, Article 3: Third Tissue Homotransplantation Conference. By John Marquis Converse, Blair O. Rogers and 75 other authors. Pp. 539–868. Vol. 73, Article 1: Enzymes in Blood. By L. P. White and 81 other authors. Pp. 1–384. (New York: New York Academy of Sciences, 1958.) [1011

Department of Scientific and Industrial Research, New Zealand. Information Series, No. 16: The Rabbit Problem in New Zealand. By Walter E. Howard. Pp. 47. (Wellington: Government Printer, 1958.) 4*s*. [1211

Annales de l'Institut de Physique du Globe de l'Université de Paris et du Bureau Central de Magnétisme Terrestre, Tome 29. Pp. 170. (Paris: Université de Paris, 1958.) [1211

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